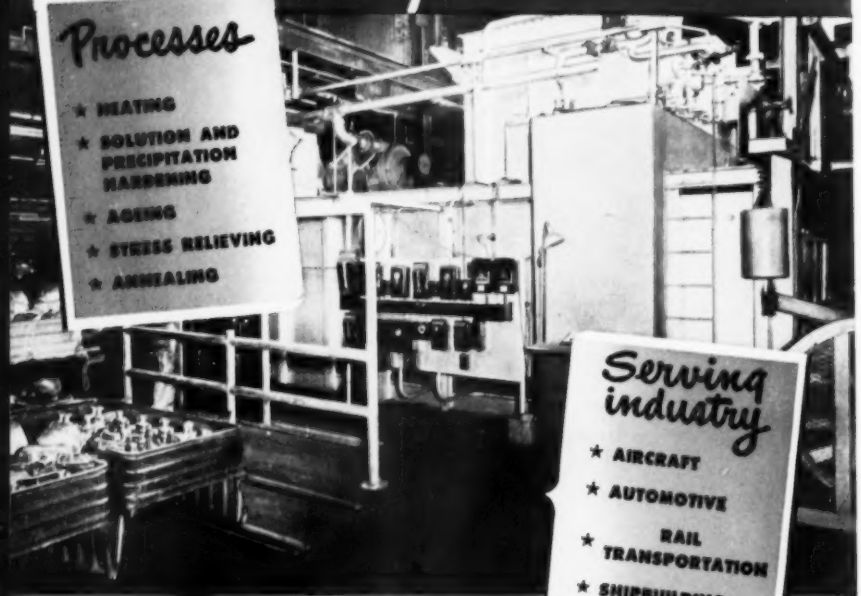
february 1953

'Surface'



HEATING ALUMINUM cylinder head forgings at Tube Turns, Inc., Louisville, Ky. 'Surface' Combustion convection heated slat conveyor furnace operates at 900 F, producing 4600 lbs/hr net.

Gas-Fired furnaces for heat treating aluminum

Why use 'Surface' furnaces?

Surface Combustion developed the forced convection type of furnace, which provides maximum temperature uniformity for heat treating aluminum. Also, convection overcomes the reflective properties of aluminum, heating the charge faster and more uniformly than other types of heating. Gas-fired salt bath furnaces for the heat treatment of aluminum and aluminum alloys are also available for special applications.

If you have unusual production requirements, odd-shaped parts, particular shop practices, or space limitations, there's a 'Surface' heat treat furnace to meet your requirements.

Write today.

SURFACE COMBUSTION *Corporation*

TOLEDO 1, OHIO

'Surface' INDUSTRIAL FURNACES AND BURNERS

Kathabar HUMIDITY CONDITIONING SYSTEMS

Janitrol AUTOMATIC HEATING EQUIPMENT

PRODUCTION BRIEFS

Typical of the jobs being done with 'Surface' furnaces in the aluminum processing industries.

FORGING

Continuous slat type conveyor furnace heats billets 8 inches in diameter and 11 to 14 inches long for cylinder head forgings.

Production—4600 lbs/hr net.
Temperature—900F.
Heat Source—A direct gas-fired air heater burning low pressure natural gas.
Size—48.5 feet long and 11.5 feet wide.

SOLUTION HEAT TREATING

Batch-type pit furnace with built-in recirculating fan heats miscellaneous aircraft parts.

Production—2666 lbs/hr net.
Temperature—970F.
Heat Source—Gas-fired radiant tubes burning low pressure natural gas.
Size—Effective pit of 5 foot diameter and 12.5 foot depth.

HOMOGENIZING

Double end batch-type car-bottom furnace with built-in recirculating fan, heats billets of heat treatable aluminum alloy 12 inches square by 60 inches long.

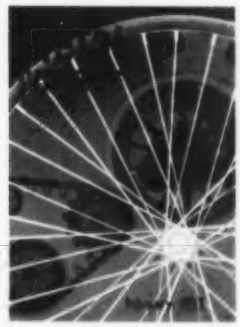
Production—18,000 lbs/hr net.
Temperature—950F.
Heat Source—Gas-fired radiant tubes burning low pressure natural gas.
Size—60 feet long and 16.5 feet wide.

ANNEALING

Continuous chain conveyor furnace heats foil of .026 inches thickness in coils 26 inches in diameter and 27 to 30 inches high.

Production—1200 lbs/hr net.
Temperature—650-780F.
Heat Source—A direct gas-fired air heater burning low pressure natural gas.
Size—33 feet long and 9 feet wide.

IN THIS ISSUE



A variety of metal wheels suggested an interesting cover design to Student Glenn Imhoff of Cleveland School of Art.

Increasing Metal Supplies

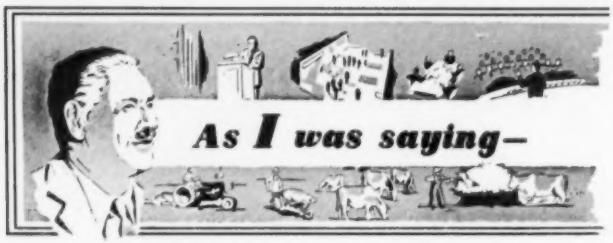
Ingenuity in Fabrication

Hazards and Difficulties

Products Using Metals

Table of Contents — p. 65
Manufacturers' Literature — p. 23
New Products — p. 19
Advertisers' Index — Last page

• *See Bill's Column on the other side* ➡



IT WAS ONLY 24 short years ago that the first Western Metal Congress and Exposition was held in Los Angeles, and here we are again. The energy, optimism and go-get-it spirit that have characterized Los Angeles since its early days were instrumental in the A.S.M.'s coming to the West Coast with a Congress and Exposition. It was at the Detroit convention in '26 that a delegation of active Los Angeles members arrived to confer with the Board of Trustees about the possibility of a Western Show. The committee pointed out that the eleven western states were an empire by themselves; that it was the fastest growing section in the U.S.A., and in addition to its wonderful climate it possessed a tremendous manufacturing activity and potential. My! What prophets they were.

The Shrine Auditorium was engaged and the first Western Metal Congress and Exposition was held in the early part of January 1929. It turned out to be a tremendously successful event.

We followed the Los Angeles meeting with one in San Francisco in the spring of 1931. Then came the "G—D—" (Great Depression) when business conditions did not permit the holding of a Western Congress and the Expositions were not resumed until '38 and '41.

And now here we are in dear old Los Angeles putting the finishing touches on the Eighth Western Metal Congress and Exposition, and I'm glad to report that both Exposition and Congress are going to be outstanding in every respect.

The A.S.M. sessions will present 37 papers, all of which have been approved by the Publications Committee and will appear in *Transactions*. The Zirconium Symposium will be published in a bound volume.

Besides the A.S.M. program at the Western Congress, technical sessions will be held by the western sections of the A.W.S., A.I.M.E., S.N.T., S.A.E. and the A.F.S., while the divisions of some 19 national technical societies are cooperating in this event for the western states.

All technical sessions will be held in the fabulous new Los Angeles Statler, while the Exposition will be held in the Pan-Pacific Auditorium and in an adjacent Pavilion. The Exposition, with 275 exhibitors, will be the largest industrial show ever held in the West. The expected attendance is 25,000 metals engineers.

Many of the same fine members are working on the committees in '53 who worked with me in '29. I couldn't name them all here without monopolizing many pages of M.P. However, all these West Coast fellows make a wonderful gang; they put their shoulders to the wheel, push the wagon out of the mud; they get things well done in a hurry, and they all know from experience: "There's gold in them thar hills."

It would be a fine idea if all (72) of you who read this column would come to California for the annual midwinter* A.S.M. meeting during the week of March 23 through 27. It will be a fine trip, a fine meeting, a splendid show, and you will feel lots better for having rolled down the cover to your desk.

I hope to be seeing you in L. A.

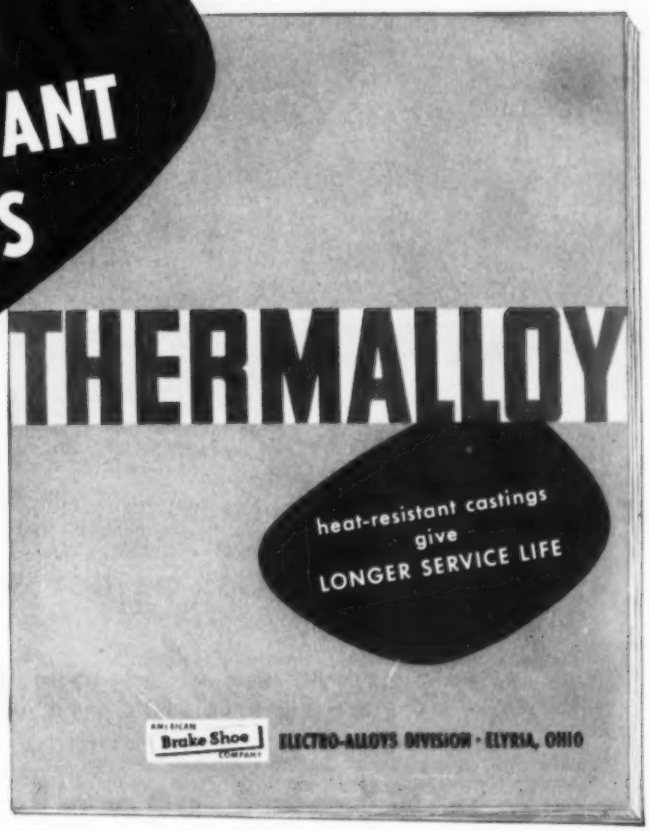
Cordially yours,

Bill

W. H. EISENMAN, *Secretary*
AMERICAN SOCIETY FOR METALS

*Term used by special permission of the Los Angeles Chamber of Commerce. It has reference to time only, not a condition of the atmosphere.

here's help
in ordering
HEAT-RESISTANT CASTINGS



NEW BOOKLET
gives complete information about THERMALLOY*

Ordering the *right* heat-resistant castings that give you top performance with the longest service life . . . requires a careful analysis of your problem. At Electro-Alloys, you will find the trained personnel and facilities needed for this service.

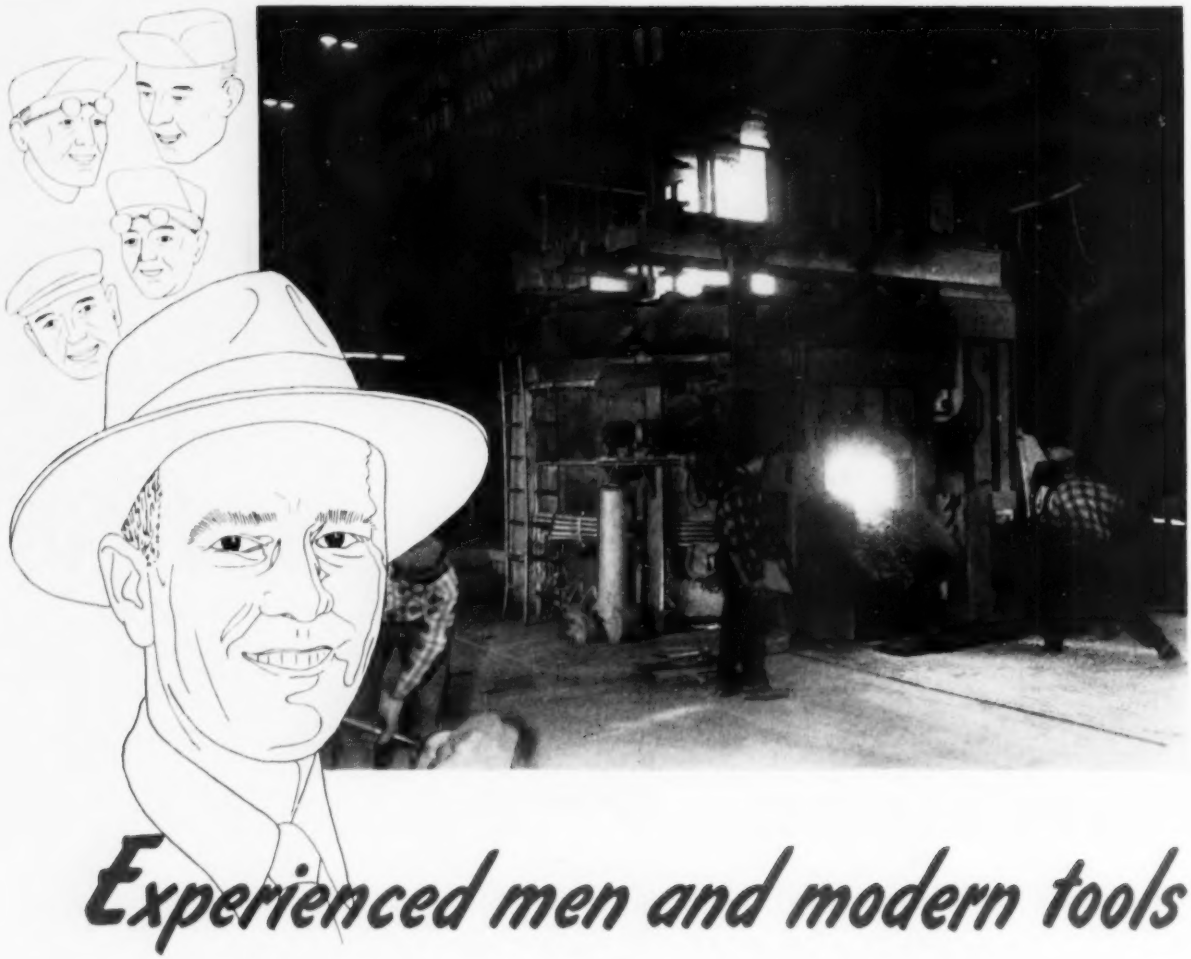
This new, 16-page, illustrated booklet will give you the complete story . . . with photographs of modern foundry facilities . . . case histories of Electro-Alloys design and engineering help . . . suggested Thermalloy applications for your industry . . . technical charts that give you detailed performance figures for the various grades of Thermalloy.

For your answers to how Electro-Alloys can help you with Thermalloy heat-resistant castings, write for your free copy today . . . Electro-Alloys Division, 4002 Taylor Street, Elyria, Ohio.

*Reg. U. S. Pat. Off.

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION
ELYRIA, OHIO



Experienced men and modern tools

make Finkl steels the finest

Whether it's 35 tons of special alloy analysis or a quality carbon heat, the experience of steel men like Dave, Bruce, Roy, Lennie, and Chick plus modern tools such as the new electric furnaces shown above combine to make Finkl steels the finest available.

Each heat is constantly checked and carefully controlled, for here is where Finkl quality begins. Here is where we start proving that the finest product is the least expensive to you in the long run.

Since 1879, Finkl has developed many special analysis steels of their own through the desire to constantly improve and to produce the finest die blocks and forgings at the lowest cost to you.

A. Finkl & Sons Co.

2011 SOUTHPORT AVENUE • CHICAGO 14

ELECTRIC FURNACE STEELS • DIE BLOCKS • FORGINGS

"Dial" Carbon

AS YOU DO TEMPERATURE

● Whether you're production heat treating small parts or bulky parts . . . gears or large shafts . . . Microcarb control provides a precise and easy method of regulating surface carbon.

With Microcarb, you can "dial" the carbon you want as easily as you'd set the temperature . . . the instrument then *directly* measures and controls the active carbon in the atmosphere surrounding the work. It is the *only* "closed loop" carbon control available.

This new Microcarb control is integrated with the long established Homocarb Method of heat treating. To provide a heat that is unusually uniform throughout the load, the scientifically designed Homocarb furnace incorporates an advanced combination of fan housing and work support, with aerodynamically designed discharge jets . . . a solid bottom retort . . . a powerful fan.

For further information, write Leeds & Northrup Co., 4927 Stenton Ave., Phila., Pa.

CARBURIZING GEARS—These nickel-chromium-molybdenum steel aircraft gears manufactured by W. H. Nichols Co., of Waltham, Mass., are a "natural" for Microcarb control. The operator simply sets the carbon controller to the percent carbon desired—Microcarb does the rest.

HARDENING AIRCRAFT PROP SHAFTS—Parts of A.M.S. 6415 steel are easily hardened by Taft-Peirce Mfg. Co. of Woonsocket, R. I. in their Homocarb furnace with Microcarb control. Six 125-lb., 30 x 6 inch shafts are run at one time, and *all* specifications are being held without difficulty on *every* load.

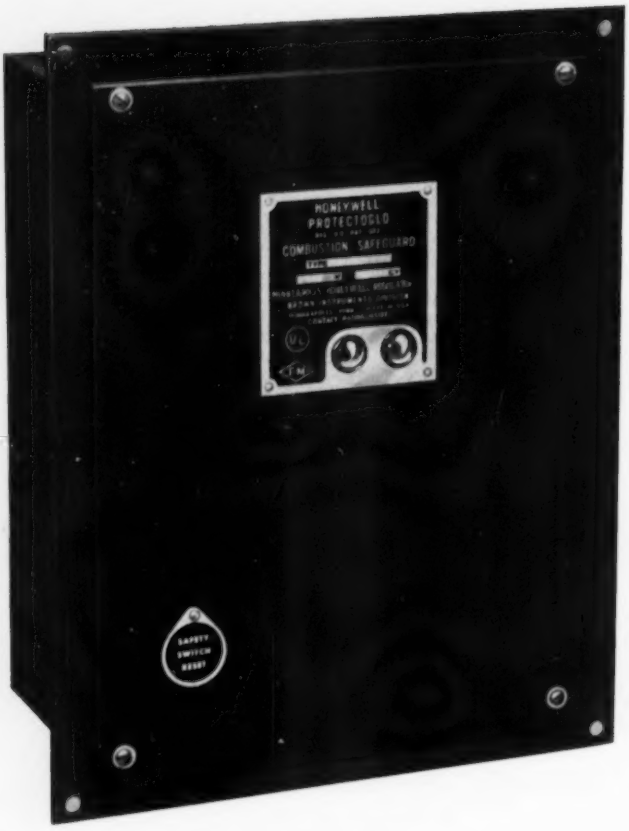
HEAT TREATING A VARIETY OF COMPONENTS—With Microcarb, Jones & Lamson Co., Springfield, Vt. efficiently carburize machine tool parts such as the adjusting cone (left) or prevent carburizing and decarb of such parts as the Universal ball bearing slide (5% Cr. 1% C steel) at right.

LEEDS & NORTHRUP

instruments • automatic controls • furnaces

Jrl Ad T-623(32)

Metal Progress is published and copyrighted, 1953, by American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio. Issued monthly; subscriptions $7.50 a year. Entered as second-class matter Feb. 7, 1921, at the post office at Cleveland, Ohio, under the act of March 3, 1879.



★ It's Foolproof Flame-Failure Protection!

The *Protectoglo* depends on the ability of a flame to rectify an alternating current. Unlike other safeguards which depend solely on flame conductivity, the *Protectoglo* can't be misled by moisture, soot accumulations or accidental short circuits . . . has 100% ground-out protection. It permits the fuel valve to remain open *only* when the flame is present.

★ It's "Fail-Safe" in Design

It automatically shuts fuel off in the event of electrical or mechanical failure in the external circuit.

★ It's Fast

Overall response of 3 seconds gives quick, safe shutdown . . . avoids false action due to flame flicker.

New **Protectoglo** combustion *makes any fuel-fired*

Choose the flame detector unit that your furnace needs

Flame Rectifier Pilot . . . a combined flame-electrode rectifier and pilot gas burner assembly.

PhotocellRectifier—ideal for use with luminous flames.

Angle Type Flame Electrode Rectifier for non-luminous gas.

Straight Flame Electrode Rectifier for non-luminous gas.

★ It Prevents Premature Re-Lighting

A new feature provides added safety in re-lighting burners. When desired, an integral purge timer prevents re-lighting for a preset interval . . . from 2 to 8 minutes . . . during which unburned gases are exhausted from the combustion chamber. A green light comes on at the end of the period, signalling that the burners may be started.

★ It Checks Itself—Starts Safely

If any component of the *Protectoglo* should fail, start-up is prevented and the main fuel valve is not permitted to open. And if the flame does not ignite within 15 (or 45) seconds after attempted start-up, the relay shuts down on "safety."

★ It Works With Any Fuel . . . Any Furnace

A selection of electrodes and photocell rectifier units provide ample choice for gas, oil, or combination fuels . . . luminous or non-luminous flames.

★ It Uses Standard Wiring

Shielded cable is not required. The *Protectoglo* system is listed and approved by the Associated Factory Mutual Laboratories.

safeguard *furnace safer*

Your local Honeywell engineering representative will welcome the opportunity to discuss how *Protectoglo* can make your furnaces safer to operate. Call him today . . . he is as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR Co., *Industrial Division*, 4503 Wayne Ave., Philadelphia 44, Pa. Sales and Service Offices in principal cities throughout the world.

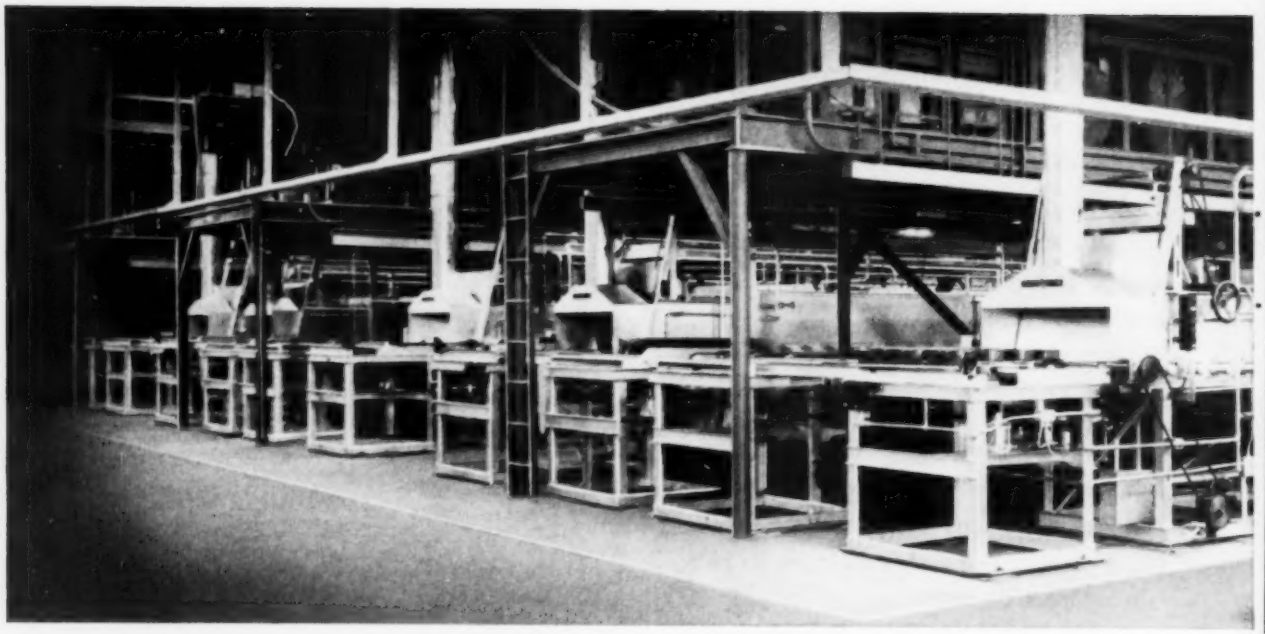
Multiple Burner *Protectoglo*
Saves space . . . centralizes protection

This new model *Protectoglo* provides convenient, economical flame-failure protection for multiple-burner furnaces, ovens and kilns. In one cabinet, it centralizes protection for 2 to 16 burners.

Each separate flame detector unit has its own relay and flame failure signal light. Several different burner lighting methods can be supplied; sequence light-off, in which burners light in series; unison light-off; and independent light-off, in which each burner system functions without interlock with the others. Automatic purge timer is available, to provide a variable period before relighting during which combustion gases can be exhausted from the furnace.

● **REFERENCE DATA:** Write for Bulletin 9602, "*Protectoglo* Combustion Safeguard" . . . and for Bulletin 9604, "Multiple Burner *Protectoglo* Systems."

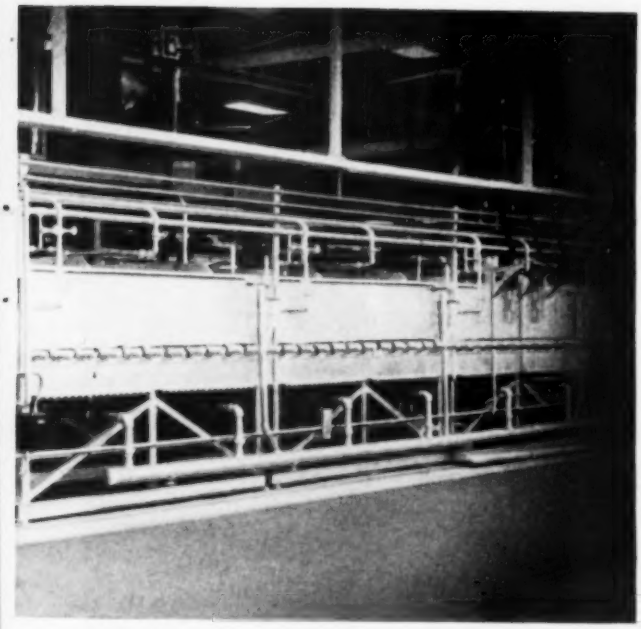
MINNEAPOLIS
Honeywell
BROWN INSTRUMENTS
First in Controls



THE EXACT EQUIPMENT to fill your requirements can usually be built from existing G-E designs. Like these five standard roller-hearth annealing furnaces, your equipment can be shipped quicker and will cost you less. G-E Heating Specialists, located in major cities throughout the country, have wide knowledge of your heating

Why You Should Ask For a G-E Bid

CORRECT INSTALLATION is an accepted fact when you specify G-E equipment and supervision. This electric furnace and induction preheat section were designed to meet customer's exact requirements for continuous annealing and galvanizing of steel strip. Experienced installation men supervised the complete set-up.



processes and can assist you in selecting the proper furnace or induction heater. Let him help you to solve *your* problem, as he did for this plant . . .

THE PROBLEM: To sinter carbides at 3000F, in a neutral atmosphere, with temperature variation of ±0.1%. *Standard* G-E equipment fit each requirement.

On Furnaces and Induction Heaters

FAST SERVICE WORK? During World War II, six huge elevator furnaces annealed aluminum at a southern plant. When their Chicago plant opened, the Chicago G-E Service Shop quickly dismantled and transported these furnaces to the new plant, then rebuilt and erected them as bell-type furnaces. The shop nearest you is just as willing to do the large or small repairs you may need—and their phone is answered at any hour.

THE RESEARCH DISCOVERIES and engineering advances in heat-treating made by G-E laboratories are passed on to you as better equipment, and as invaluable process information. From General Electric has come such developments as furnace brazing, the first resistance-electric furnace, stepless temperature control for electric furnaces, the first protective gas-atmosphere producer plus pioneering work on electronic induction heating. We shall continue to earn your respect and business by providing the highest quality equipment and the most advanced designs to fit your exact needs.

WHEN YOU DEAL WITH G-E on heating equipment, here is what you receive: (1) proper equipment from hundreds of existing designs—or we will build special equipment to suit your needs (2) correct installation supervised by experienced men (3) experienced application men to help solve your heating process problems (4) fast repair work from nearby G-E Service Shops (5) plus development leadership on products and processes. Consider G-E equipment for these heating processes: brazing, sintering, porcelain-enameling, wire-enameling, general heat-treating, and annealing malleable iron.

ASK FOR THE SERVICES of a G-E Heating Specialist when you have heating problems or are considering new heating equipment—call the nearby G-E Sales Office, or write General Electric Company, Schenectady 5, N. Y. Consider well his proposal for it is no idle boast when we say of G-E furnaces and induction heaters . . . 720-100

You can put your confidence in—

GENERAL ELECTRIC

there's real ventilation— 24 air channels in every H-VW-M Ruff-L-Buff!

Evenly distributed ventilation, too. That means air-cooled operation even under severest use—more pressure without burning—faster cut—more composition mileage—and longer life for the buff. Air rushes into those extra large holes at the center, circulates right through the wheel, and escapes at the face. This constant flow of air—plus the fanning effect of the ruffles at the face—*eliminates excessive heat.*

Now take a look at the rest of these features: There's an extra safety factor in the rugged steel ring that anchors the cloth at the center; every buff is perfectly balanced; and that exclusive H-VW-M Red-E-To-Use Face is all set to take composition without raking or truing. Ruff-L-Buffs are available in a wide variety of types and weights for any application—to do a *better* buffing job for *you.*

Top quality buffs are just one of many results of over eighty years of constant electroplating and polishing development—a continuing policy summed up in H-VW-M Platemanship . . . your working guarantee of the best that industry has to offer—not only in buffs—but in every phase of plating and polishing. 0593

PLATEMANSHIP

PLATEMANSHIP — PLATING & POLISHING — ROCHESTER EQUIPMENT SUPPLIES

For full information on Ruff-L-Buffs as well as all H-VW-M buffs ask for Bulletin B-100.

HANSON-VAN WINKLE-MUNNING CO. MATAWAN, NEW JERSEY U.S.A.

Your H-VW-M combination—of the most modern testing and development laboratory—of over 80 years experience in every phase of plating and polishing—of a complete equipment, process and supply line for every need.

HANSON-VAN WINKLE-MUNNING CO., MATAWAN, N. J.
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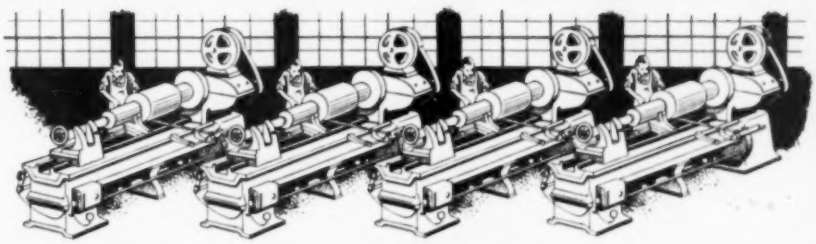
H-VW-M

INDUSTRY'S WORKSHOP FOR THE FINEST IN PLATING AND POLISHING PROCESSES • EQUIPMENT • SUPPLIES

Tool Steel Topics

BETH-EHEM STEEL

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.



Output up 150 pct with Red Sabre Bits

Four identical lathes, side by side, produced identical parts in one of our customer's shops. Using both high-speed steel and carbide tool bits, the rate per shift was set at 150 pieces per machine by the time-study engineers.

One of the lathe operators heard about our Red Sabre tool bits from a friend. So he brought one to work and began using it. He surprised himself by finishing 325 pieces in one shift, earning a nice bonus.

When he kept up his high rate, the payroll department began to ask questions. But a check-up showed that the operator's production was being reported correctly. In fact, his output increased to an average of 370 pieces.

When the time-study men got to the bottom of the mystery they really became enthusiastic. Red Sabre bits were installed on all four lathes. Output reached as high as 400 by increasing speeds and feeds.

Red Sabre bits are mighty popular in this shop because both the machine operators and the management are reaping the benefits of the increased output.

Red Sabre is our super high-speed steel. It has more wear-resistance and higher red-hardness than run-of-the-mill tool bits. Red Sabre tool bits, hardened to a minimum of Rockwell C-65 and ground accurately, are available in all standard sizes.

Like to try them in your shop? Order a couple from us at Bethlehem, Pa., or ask your distributor about a trial.

HIGH-PRODUCTION DIE

This blanking, drawing, and forming die is made of high-carbon, high-chromium tool steel (our Lehigh H) to make possible long production runs. Operated in a 350-ton press, it produces end caps for a refrigeration unit. Hardened to Rockwell C-60, this die turns out about 100,000 pieces from 3/16-in. steel strip before redressing is needed. An air-hardening grade of tool steel, Lehigh H provides very high wear-resistance and the least amount of distortion during heat-treatment.

(Left) A kitchen-ware maker uses BTR* for the die that blanks and draws .032-in. aluminum to accurate size. The fit between the die halves is held to close tolerance to assure proper flow of metal during the one-stroke draw and to produce a smooth surface. This die has produced more than half a million pieces.

(Right) In a single operation these piercing dies, made of our BTR* tool steel, put 125 holes in the aluminum accessory for pressure cookers shown at the right. The punches were in excellent alignment after heat-treatment, and showed little evidence of wear after producing 165,000 pieces without requiring regrinding.

**BTR is an economical, general-purpose tool steel. Oil-hardening, it's easy to machine and heat-treat. Tough and wear-resisting, it's low in distortion.*

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Remedy those fatigue-failures

Tools such as chisels, that are subjected to repeated stresses, often fail suddenly. As the tools are made from shock-resisting steel, these sudden failures can look mysterious. But close examination of the failed parts will often reveal that the failures were actually not sudden but occurred by progression of a crack part way through the section, followed by sudden fracture of the remaining section.

Fatigue-fractures have a characteristic, smooth-rubbed surface where the initial crack opened up, and an inner crystalline zone revealed by the final sudden break. Often the smooth-rubbed surface shows parallel "oyster-shell" markings, and may even show evidence of rusting.

Fatigue-failures usually begin at a stress-concentration point. This may be a notch, a poor fillet, tool mark, accidental nick, or a stamping. Correcting such design or mechanical faults is the cure.

The Company faced with cold forming this thread rolled depressed head machine screw said, "We just *wouldn't* attempt to make it from *any* standard grade of 18-8!"

When this Company was asked to produce a second lot of these sheet metal screws from a regular 18-8, here was the reply: "Impossible —there's too much punch breakage!"

What would *you* do

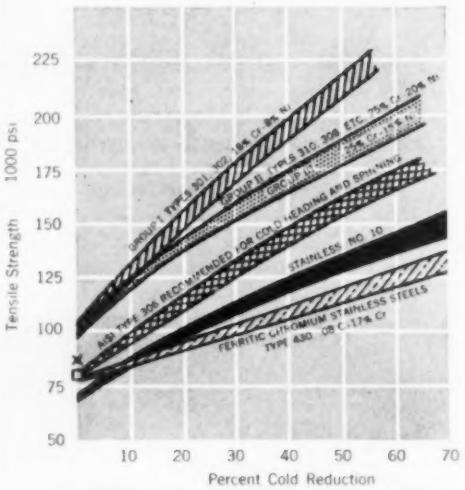
if you had to
mass produce
these fasteners
from 18-8 stainless
...without "losing your shirt"?

Both jobs were produced economically from a totally NEW chrome-nickel stainless!

Both companies successfully turned out these jobs with new Carpenter Stainless No. 10—the first chrome-nickel Stainless to permit economical, mass production of severely cold headed and upset fasteners and other parts. Carpenter No. 10 work-hardens far slower than any of the conventional 18-8 grades. That's the secret of its success. That is why it is ideal for cold headed bolts, screws, and upset nuts made on automatic machines. In fact, it is suited for any job involving heading, extrusion, severe coining and swaging. And the corrosion resistance of No. 10 is slightly better than Types 302, 304 and 305.

Of course, because of its high nickel content, Carpenter No. 10 is subject to present government regulations, and its supply is limited. Yet, we always like to keep you informed about the possibilities of a product like this. Upon request, we will be glad to give you more information about No. 10—its corrosion resistance, cold workability, machinability . . . as well as its usefulness for parts that must remain non-magnetic after severe cold working. So drop us a line on your Company letterhead, now . . . or any time. THE CARPENTER STEEL COMPANY, 133 W. BERN ST., READING, PA.

Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"



Comparison of various Stainless Steels showing increase of tensile strength with percentage of cold reduction.

Carpenter STEEL

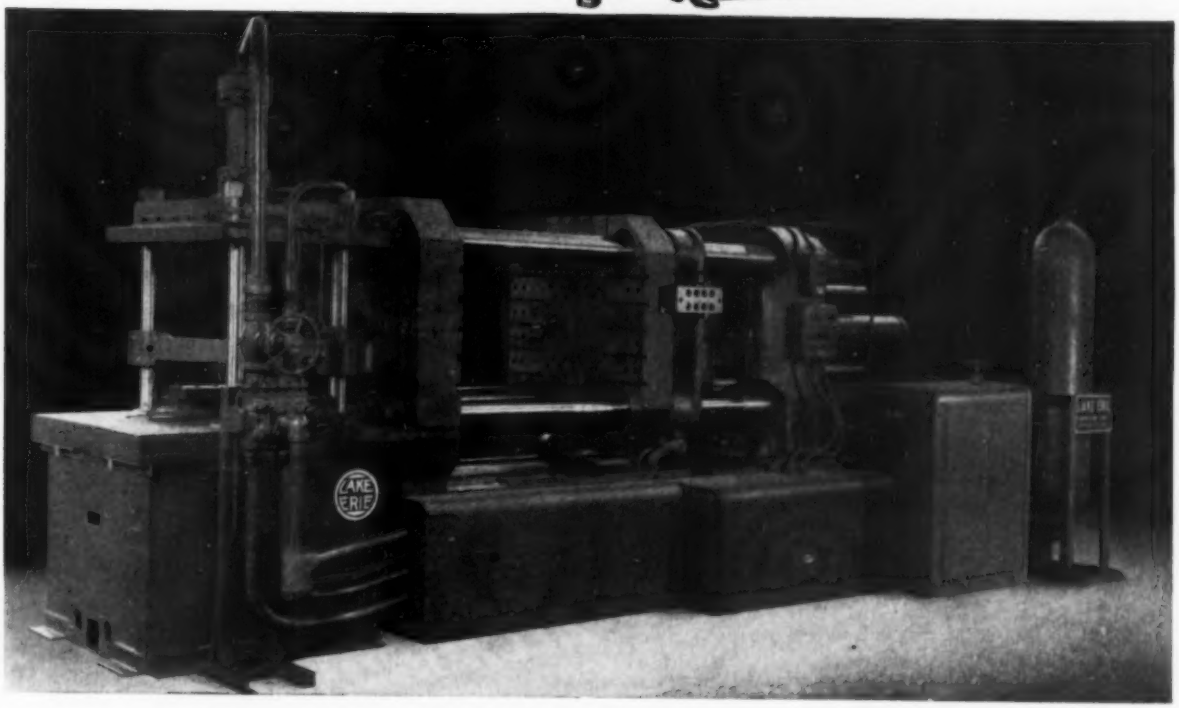
Stainless No. 10

takes the problems out of production

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research

Have you investigated the new Lake Erie Die Casting Machines?

THESE REVOLUTIONARY MACHINES ARE INCREASING PRODUCTION AS MUCH AS **15% to 25%** FOR LEADING DIE CASTERS



FEATURING

- PATENTED "WEDGE CAM" TOGGLE
- PATENTED "PRESSURE-PAC" INJECTION UNIT

Choice of 10 Models from 100 to 1000 tons for zinc, lead, tin, aluminum magnesium and brass. Write for complete details and Bulletin 23.1.

LAKE ERIE
ENGINEERING CORP.
BUFFALO, N.Y. U.S.A.

MANUFACTURERS OF HYDRAULIC PRESSES AND DIE CASTING MACHINES

★

General Offices and Plant
620 Woodward Avenue, Buffalo 17, N.Y.

District Offices in
NEW YORK • CHICAGO • DETROIT and PITTSBURGH
Representatives in Other Principal Cities in the United States and Foreign Countries

Manufactured in Canada by Canada Iron Foundries Ltd.
LAKE ERIE ®

LAKE ERIE HYDRAULIC PRESSES are available in any size... standard, modified and special designs—horizontal and vertical types—for Metal Working—Plastics Molding—Forging—Metal Extrusion—Processing—Vulcanizing—Laminating—Stereotype Molding—Die Casting—Briquetting—Baling—Special Purpose

U. S. Air Force crash trucks and rescue vehicles by American-LaFrance-Foamite Corp., Elmira, N. Y., use Revere Aluminum.

Aluminum Conductor Busway, light and economical, by Bull Dog Electric Products Co., Detroit, Mich., uses Revere Aluminum (EC Grade) Bar.

Industry Depends Upon The Versatility Of REVERE ALUMINUM

Revere meets the requirements of industry with a wide range of aluminum alloys in extruded shapes, coiled sheet, drawn tube, electrical bar and forgings. And industry knows the fine, uniform quality of Revere Aluminum. Each customer's requirements, based on their specific uses of Revere products, receives careful attention by Revere quality control.

For assistance in the efficient manufacture of products using aluminum, you are invited to utilize Revere's Technical Advisory Service.

REVERE ALUMINUM

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N.Y.

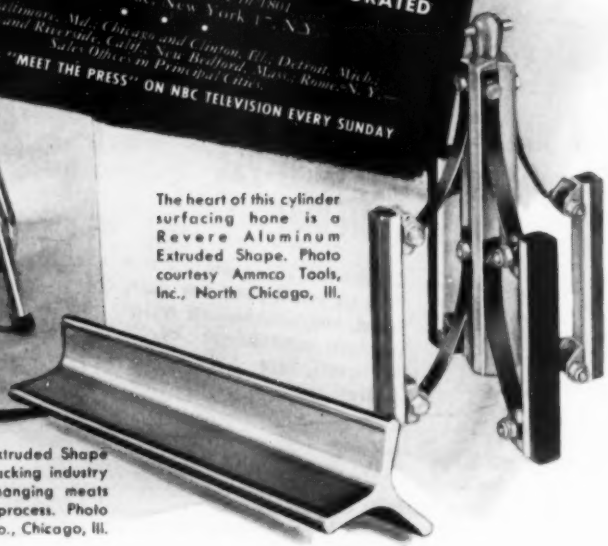
Mills: Baltimore, Md.; Chicago and Clinton, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Rome, N.Y.

Sales Offices in Principal Cities

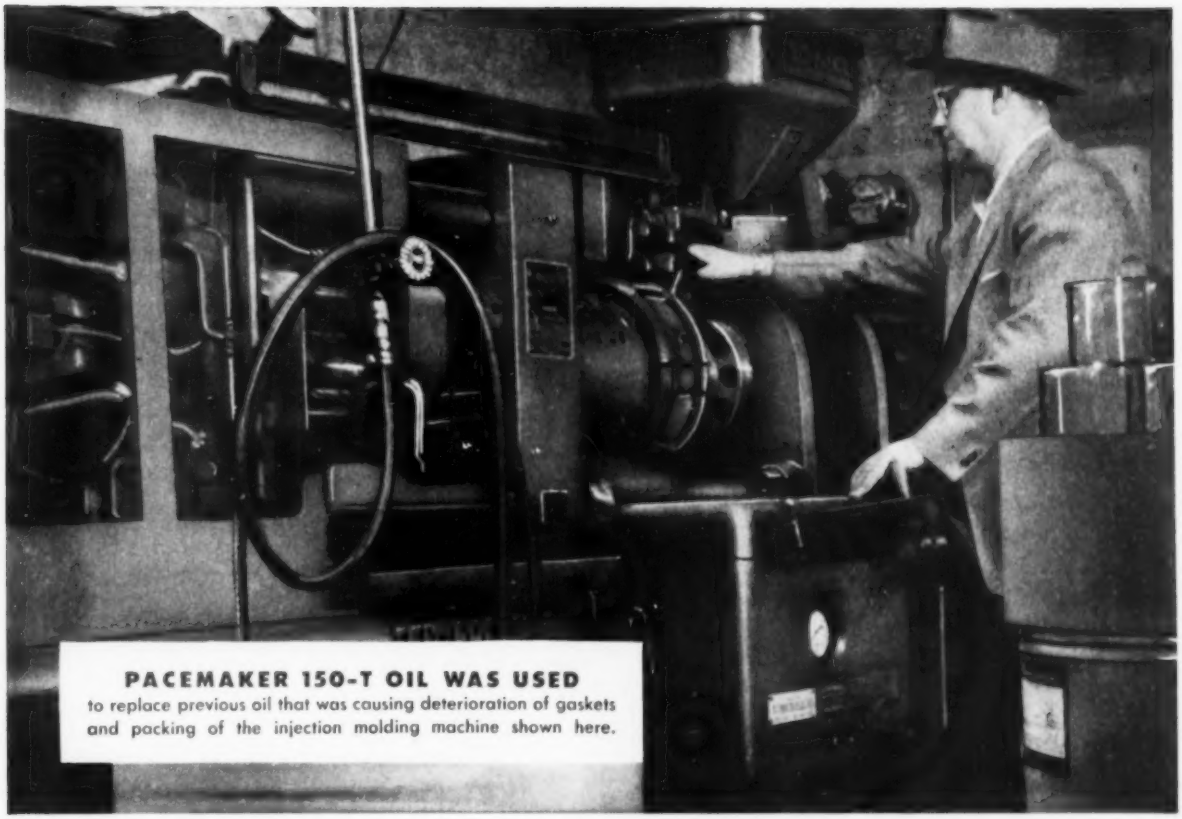
SEE REVERE'S "MEET THE PRESS" ON NBC TELEVISION EVERY SUNDAY

Many makers of indoor and outdoor chairs and furniture use Revere Aluminum Tube. This chair by Lawnlite Co., Miami, Florida.

The heart of this cylinder surfacing hone is a Revere Aluminum Extruded Shape. Photo courtesy Ammco Tools, Inc., North Chicago, Ill.



A Revere Aluminum Extruded Shape is used by the meat packing industry as smoke-sticks for hanging meats during the smoking process. Photo courtesy The Globe Co., Chicago, Ill.



PACEMAKER 150-T OIL WAS USED
to replace previous oil that was causing deterioration of gaskets and packing of the injection molding machine shown here.

PACEMAKER 150-T OIL SAVES MANUFACTURER UP TO $600.00 PER MONTH

The injection molding machine (shown above) of Plasticks Inc. of Chicago was operating under 1000 p.s.i. at a water-controlled oil heat of 100° F to 120° F, 24 hours per day, 7 days a week.

THEN CAME TROUBLE! The hydraulic oil they were using was seriously damaging gaskets and packing. So, they called in their Cities Service Representative . . . and he recommended Cities Service Pacemaker 150-T Oil.

THE RESULTS WERE PHENOMENAL! With Pacemaker 150-T, the machine was able to run far longer on an oil change than ever before! Machine filters were cleaner with each change. Gumming and deterioration were eliminated! . . . AND DOWNTIME WAS CUT 20% to 25% AT THE AMAZING SAVINGS OF $450.00 to $600.00 PER MONTH!

You too can realize big dollar savings and increase production by relying on the full line of Cities Service Industrial Lubricants. Call your nearest Cities Service Representative, or write Cities Service Oil Company, Dept. B14, Sixty Wall Tower, New York City 5, New York.

CITIES SERVICE
QUALITY PETROLEUM PRODUCTS

we've built a GIANT

...to produce high vacuum in bigger chambers—at less cost—than ever before

Say you're producing one of the modern metals that has wonderful properties but can't stand oxygen at high temperatures.

You want to push out into the atmosphere as much air or gas as possible at the lowest cost. You may need to exhaust down to 1/2000th of atmospheric pressure or as low as 1/75,000th of an atmosphere.

CVC supplies a series of nonmechanical oil ejector pumps which can operate in this pressure range at rates well over 10,000 cubic feet per minute, compressing air and gas to the point where mechanical pumping becomes highly efficient—to pressures as high as 10 mm Hg where needed. And these unique pumps make possible a new order of operating economy for large high vacuum systems.

Whether your need is for a single pump or a complete high vacuum furnace we will welcome an opportunity to talk with you. Write to **Consolidated Vacuum Corporation, Rochester 3, N. Y.** (A subsidiary of Consolidated Engineering Corporation, Pasadena, Calif.)

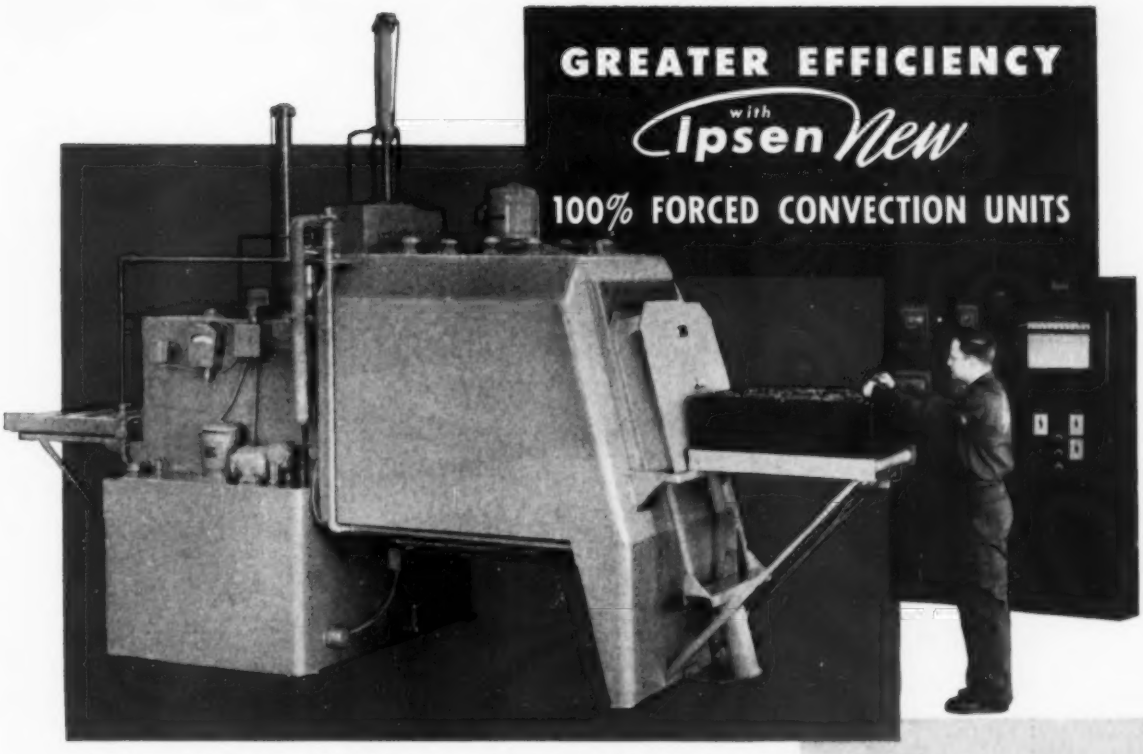
CVC

formerly DPi Vacuum Equipment Dept.

Consolidated Vacuum Corporation

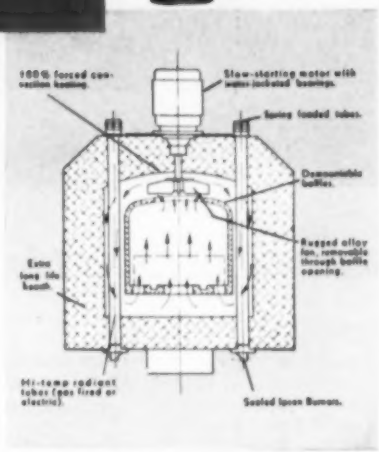
high vacuum research and engineering

GREATER EFFICIENCY with Ipsen New 100% FORCED CONVECTION UNITS



▲ *New Ipsen 400 Lb./Hr. Automatic Heat Treating Unit equipped for martempering. Straight-through operation from heat through quench, or cooling, eliminates loading delays.*

▶ *Ipsen's new radiant tube and 100% forced convection heating design. Spring-loaded tubes seal automatically. Controlled atmosphere throughout assures bright, clean, scale-free work.*



Ipsen controlled atmosphere heat treating units are designed with 100% forced convection heating to provide greater efficiency. Built for temperatures up to 1850° F., they can profitably handle a wide range of work, both in small lots and in production runs.

These are some of Ipsen's outstanding design features which will give you greater efficiency in processing:

1 **100% Forced Convection Heating**—powerful alloy fan forces atmosphere around radiant tubes, under floor, and *through* the work. Provides faster heat recovery and uniform circulation. Fan is removable through baffle opening in hearth.

2 **Long Life, Radiant Tubes** — withstand high temperatures, assure long, trouble-free service. Light in weight, are easier to remove, cost 50% less to replace.

3 **New Sealed-in Silent Burners**—provide accurate flame control, fast temperature buildup, *complete* combustion and uniform temperature.

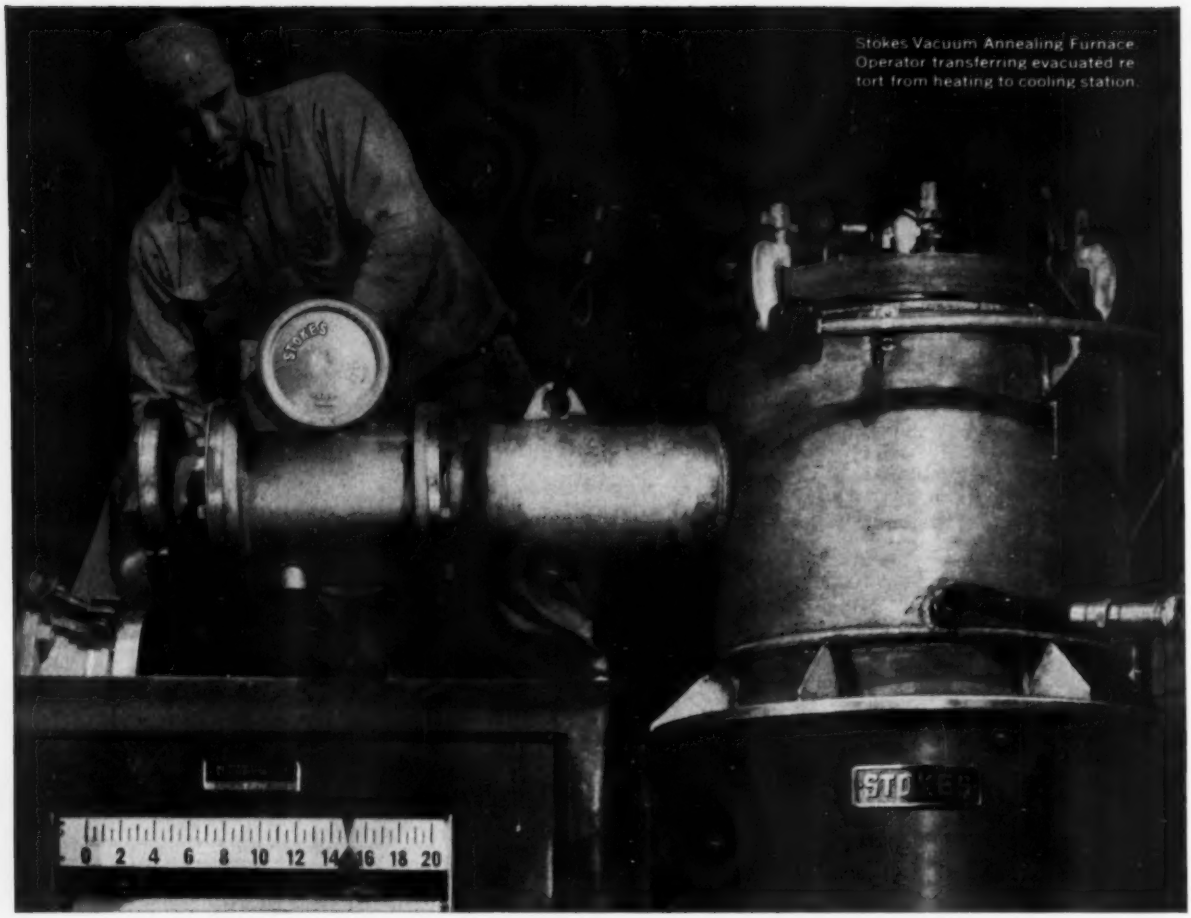
4 **Demountable Baffles** — assure complete circulation of atmospheres through the load and maintain uniform work temperature. Sectional-type construction permits easy replacement. Complete unit can be removed in ten minutes.

AUTOMATIC Ipsen

Send **Samples for Free Estimate** — find out how the new Ipsen Units can be applied to your job. Samples of your work will be run, procedures established in our new, modern lab, and cost estimates given without obligation.

Write **for New Literature** — illustrates new design features, gives complete specifications of various units.

IPSEN INDUSTRIES, INC. 723 South Main Street; Rockford, Illinois
Universal Units for CARBONITRIDING · CARBURIZING · HARDENING · BRAZING · MARTEMPERING



Stokes Vacuum Annealing Furnace. Operator transferring evacuated retort from heating to cooling station.

Make the step... from laboratory to production with Stokes High-Vacuum equipment

For processing titanium, zirconium, hafnium, and other metals . . . for low-cost melting, annealing and sintering of metals which must be processed under vacuum, Stokes makes the vacuum furnaces.

For the production of all high-vacuum processing equipment, Stokes has the largest and most diverse manufacturing facilities.

We build to customers' requirements, with a sure knowledge of what *is* and what is *not* practical.

Stokes techniques of building vacuum processing equipment which *works* and *produces in bulk* at low cost have been developed during fifty years of experience with vacuum and high vacuum.

Visit the Stokes plant and see for yourself that Stokes is first in Vacuum . . . first in the manufacture of vacuum processing equipment which takes you over the gap between the laboratory and commercial production.

F. J. Stokes Machine Company,
Philadelphia 20, Pa.

STOKES

STOKES MAKES Plastics Molding Presses / Industrial Tabletting and Powder Metal Presses / Pharmaceutical Equipment / Vacuum Equipment / High Vacuum Pumps and Gages / Special Machinery

Reynolds
ALUMINUM REPORTER

★ ★ ★ Twelfth in a Series to Industry on Aluminum Uses and Developments ★ ★ ★

ALUMINUM EFFICIENT IN FRAMELESS BUILDINGS

Many Important Sales Advantages Displayed in Popular Aluminum Tension Screens

Simple installation, easy operation, long life and comparatively low cost are prime features of the aluminum tension screens made by the Ry-Lock Company Ltd., of San Leandro, California. These builder and owner advantages are heightened by the use of rustproof, rotproof, always attractive aluminum in both screens and screen framing.

Ry-Lock, the first aluminum tension screen manufacturer in the country, uses Reynolds Aluminum exclusively in their quality line of tension screens for wood and metal windows of all types. Clingan and Fortier, Inc., one of the Reynolds Distributors in Los Angeles and San Francisco, serves the Ry-Lock Company with aluminum for screen bars and hardware fittings.

Ry-Lock Tension Screen installed on casement window.

The aluminum construction gives Ry-Lock sales advantages not provided by other materials. There is nothing to rot or warp. Aluminum does not require painting yet blends with any color scheme. Furthermore, users can be assured that surfaces adjoining the aluminum screens will not be streaked with rust or corrosion stains.

Tension screens manufactured and distributed under the "Ry-Lock" name in the eleven Western states are a product of the Ry-Lock Company. The New York Wire Cloth Company has been licensed to manufacture and distribute them in the other thirty-seven states under the name "Durall."

For a free copy of Reynolds 1953 Product Design catalog, and a complete index of technical literature and movies, write to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Behlen Manufacturing Company Opens Broad New Fields In Modern Building Design and Construction

Fourteen tractors, weighing 32 tons, suspended from roof ridge of frameless Behlen aluminum building. Insets show alternate methods of eave construction.

Ample proof of what you can accomplish with aluminum and good design, is found in the popular frameless aluminum buildings produced by the Behlen Manufacturing Company of Columbus, Nebraska.

Designed primarily for industrial, farm and military use, these straight side, frameless Behlen buildings are constructed without upright support members for walls or in the interior, and without truss support for the gable-type roof.

Deeply corrugated aluminum panels for walls and roofs are bolted together at the eaves and roof ridge to form a continuous arch. The arch sections are in turn bolted to each other to form a complete, weatherproof, load-bearing shell.

Panels for the Behlen buildings are made from .064-inch to .072-inch aluminum alloy sheets, corrugated to a depth of 7½ inches. This corrugating adds so much rigidity that each arch section has the same strength as an I beam of equivalent weight.

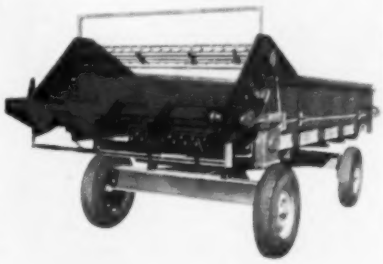
All of the important advantages of strong, light weight, rust-proof, heat reflecting, maintenance-free aluminum are utilized to the maximum by progressive Behlen engineers. To get similar advantages in your products, have a Reynolds Aluminum Specialist assist you on new or redesign problems.

Reynolds Aluminum Specialists will be glad to work with you, just as they have worked with Behlen and countless other companies. This assistance is yours without obligation through the Reynolds office or Reynolds Distributor listed under "Aluminum" in your classified telephone directory. Or write direct to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Rustproof, Acid Resistant Aluminum Plays Important Role in Manure Spreader

In this efficient combination of power box and manure spreader, the rustproof and corrosion resistant advantages of aluminum are used to withstand manure acids.

The Farmhand Power-Box sits on truck, wagon or trailer with equal ease. When connected to a source of power, the bed of the



box moves the load back to a Farmhand Spreader Attachment for the final flip that distributes manure evenly over the field.

Because of the corrosive action of manure, both pieces of equipment are made primarily of aluminum and treated wood. They are manufactured by The Farmhand Company, a division of Superior Separator Company, Hopkins, Minnesota.

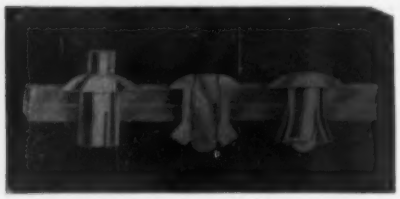
MORE INTERESTING NEWS ABOUT ALUMINUM ON NEXT PAGE

Printed in U.S.A.

(Continued From Preceding Page)

Aluminum Drive Rivets Save Production Time and Money

Aluminum rivets, nuts, bolts, screw, washer, cotter-pins and other mechanical fasteners are produced by a number of leading manufacturers who rely on Reynolds for top quality material. A typical example, is the aluminum Southco Drive Rivet, one of several aluminum fastening devices made by the South Chester Corporation of Lester, Pennsylvania.



The photograph illustrates how a hammer-driven pin expands the prongs of this patented rivet, drawing panels together in a tight, secure joint. Thus blind joints made with aluminum Southco Drive Rivets are quickly and easily completed. There's no bucking, trimming or grinding. Once driven, the inserted grooved pin cannot work loose even under severe vibration.

Use of rustproof and corrosion-resistant aluminum fasteners with aluminum assemblies prevents any possibility of galvanic reaction between dissimilar metals when they may be subjected to moisture or water.

For your free copy of the valuable handbook "Fastening Methods for Aluminum," plus a complete index of Reynolds technical literature, write on your business letterhead (otherwise the book is $1.00) to Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

Return Flight As Guaranteed

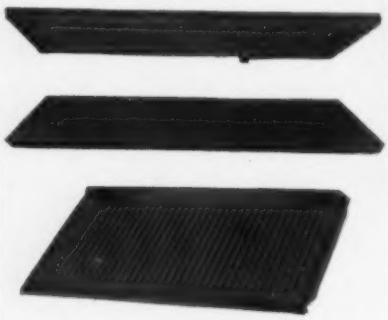
Reynolds Aluminum Foil Now Used As Facing for Glass Fiber Insulation

Gustin-Bacon Manufacturing Company, makers of Ultralite and Ultrafine glass fiber insulations, now offers this material faced with Reynolds Aluminum foil . . . another example of the fast growing list of applications for aluminum foil in many industries.

Growing Industries Rely on Reynolds Aluminum Fabricating Service

More and more companies in diversified industries are taking advantage of Reynolds complete fabricating service for aluminum parts. As an example, illustrated below are two types of aluminum shelving produced by Reynolds Parts Division for the refrigeration industry.

Vertical freezer shelves are made from Reynolds high strength aluminum alloy sheet to which aluminum tubing is cleanly and securely brazed. These shelves provide a high degree of heat transfer efficiency in addition to being rigid and durable. They are available with a plain anodized or Alodized finish. One-



piece, Reynolds Aluminum refrigerator shelving, with a corrosion-proof and chip-proof plain or color anodized finish, is also rigid and attractive.

Whether you want final assemblies, completed parts, blanks or roll-formed shapes, you'll find the extensive facilities and technical assistance of Reynolds Parts Division real value. Contact the nearby Reynolds office listed under "Aluminum" in your classified telephone directory or write Reynolds Metals Company, Parts Division, 2065 South Ninth Street, Louisville 1, Kentucky.

A one-half inch thick pad of the glass fiber with .0007-inch aluminum foil is commonly used as a furnace jacket liner. The radiant heat reflecting surface of the foil, plus the pad of insulation, keeps the jackets cooler and reduces popping noises due to the contraction and expansion of the casing. Leading manufacturers of furnaces are using more and more aluminum foil faced Ultralite and Ultrafine for this purpose.

Air conditioning ductwork insulated with foil faced Ultralite

Ultralite faced with .0025-inch aluminum foil also provides a complete vapor barrier in the insulating of air conditioning ducts. The aluminum foil barrier prevents condensation from forming on the cold duct surface or in the bulk insulation. And since aluminum, Ultralite and Ultrafine are all fire-resistant, this insulation passes city building codes. The .0025-inch foil faced Ultralite is also used extensively in the insulation of metal buildings.

The Gustin-Bacon Manufacturing Company has its general offices in Kansas City, Missouri, and maintains branch offices and distributors in a number of large cities.

For information on the application of Reynolds Aluminum foil in your products write Reynolds Metals Company, 2576 South Third Street, Louisville 1, Kentucky.

It's Sno' Fun Without A Light, Aluminum Shovel!

Here's tomorrow's weather forecast: SNOW—followed by little boys on sleds . . . and big fellows with snow shovels.

You can cut down on those backaches, however, if you have a featherweight aluminum snow shovel like the one illustrated here, that's made by the Hamlin Metals Products Company of Akron, Ohio.

Hamlin, like other manufacturers of quality products, relies on Reynolds Aluminum to add dependability plus sales appeal to their snow shovels. They make the light weight, rust-free blades with a Reynolds hard aluminum alloy.

Remember—whether you are designing or manufacturing anything from snow shovels to steam shovels, Reynolds Aluminum Specialists are ready to help you get the most from aluminum. Call your Reynolds office listed under "Aluminum" in your classified telephone directory or write Reynolds Metals Company, 2576 S. Third St., Louisville 1, Ky.

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Looking for something special?

J&L provides you with Cold Finished Steel that's—

CARBON RESTORED . . . ANNEALED
NORMALIZED . . . BRIGHT ANNEALED

Our cold finishing bar mills now include a modern controlled atmosphere furnace for the thermal treatment of cold finished steel. This latest addition to Jones & Laughlin Steel Corporation facilities can mean cash in the till for *you* . . . cash that's measured in terms of cold finished bars that lower production costs, increase output and assure top-flight quality in the finished products you are producing.

Why not get in touch with J&L *today*? We'll be glad to provide detailed information relating to your specific needs. Our contact metallurgists are available to work *with* you to determine how *you* can use these special J&L cold finished steels to gain the advantages of improved machinability, exact mechanical properties, increased ductility, or elimination of the necessity to remove "decarbed" surfaces.

JONES & LAUGHLIN STEEL CORPORATION, PITTSBURGH, PA.

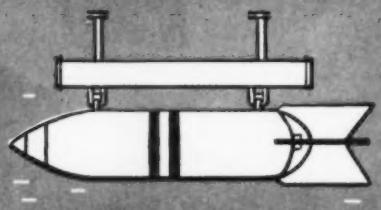
FILL IN THE COUPON NOW!

Jones & Laughlin Steel Corporation
405 Gateway Center, Pittsburgh 30, Pa.

☐ Without obligation please send me your booklet "Extra Services to Users of Cold Finished Steel."
☐ Please have your representative call.

Name _____
Title _____
Company _____
Address _____

FROM THUMB TACKS TO BOMB RACKS



you can test practically anything with a

RIEHLE

UNIVERSAL TESTING MACHINE

Every Riehle Pendomatic Universal Testing Machine is the equivalent of five testing machines in one because it has five standard scale ranges. You select the most logical range for your test; then, merely turn the selector knob and conduct your test. On the same Riehle machine, you can test specimens with relatively low-rupture-points or large, high-yield-point specimens. No accessories are needed. Guaranteed accuracy is within ½ of 1%.

Hydraulic and Screw Power Types

Riehle Universal Testing Machines are built with hydraulic loading unit or screw power loading unit. Each type is available in a variety of sizes, with capacities up through 400,000 lbs. Ask your Riehle representative or write our factory for illustrated catalogs.

60,000 lbs. capacity Riehle Screw Power Universal Testing Machine illustrated. Photo courtesy of USAF Institute of Technology, Wright-Patterson Air Force Base.

RIEHLE TESTING MACHINES

Division of AMERICAN MACHINE AND METALS, INC.

East Moline, Illinois

"ONE TEST IS WORTH A THOUSAND EXPERT OPINIONS"

Engineering Digest

OF NEW PRODUCTS

Furnace Refractory

Even though one end of the brick is incandescent — having been heated to over 2000° F. — the operator holds the brick in his bare hand. This high degree of insulating ability, combined with light weight, results in low heat capacity and makes Carborundum's Alfrax BI "bubble-brick" particularly

suited for furnace construction. Consisting of bubbles — hollow spheres of aluminum oxide specially bonded together — this refractory material is one of the most heat resistant.

For further information circle No. 242 on literature request card on p. 32B

Barrel Plating

The Hanson-Van Winkle-Munning Co. has announced new submerged barrel plating equipment which completely immerses the plating barrel in the electrolyte. All surfaces of the work receive a uniform solution bath because no part of it can be exposed to the air while tumbling. The completely submerged barrel also permits greater current density and thus faster plating. The new equipment includes both barrel and plating tank. The barrel is hexagonal, 14 in. in inside diameter, 125 and 150 lb. capacity.

For further information circle No. 243 on literature request card on p. 32B

Removal of Oxide From Copper Alloys

A procedure developed by Enthone, Inc., eliminates the use of acids in removing cuprous oxide from the surface of copper and copper alloys. The procedure involves converting the cuprous oxide to cupric oxide by the Ebonol "C" process. The black cupric oxide that is formed by this treatment is easily removed by dilute acids, such as dilute sulphuric acid, or by sodium cyanide. The process is applicable to pure copper, tin bronzes, phosphor bronzes, brasses, and copper alloys containing silicon and aluminum.

For further information circle No. 244 on literature request card on p. 32B

Preparing Aluminum Surfaces for Welding

A new process used in preparing aluminum surfaces for welding has been announced by Northwest Chemical Co. The new Alkalume process thoroughly removes all soils and oxides without harming metal, thereby reducing surface electrical resistance to a value of 0 to 10 microhms. Tests on various alloys and gages of metal indicate that production welds meet specified values for penetration and shear strength. Graphs of performance curves are available.

For further information circle No. 245 on literature request card on p. 32B

Vacuum Gage

Measuring absolute pressures from atmospheric down to 0.0001 mm., the type 511 Alphatron vacuum gage employs a principle of operation related to the conventional hot filament ionization gage. The important difference

is that this new National Research Corp. gage employs a shielded radioactive source instead of a hot filament. Alpha particles ionize the gas. Ionization current produced is measured by a d.c. amplifier which is calibrated to give absolute pressure in millimeters of mercury.

For further information circle No. 247 on literature request card on p. 32B

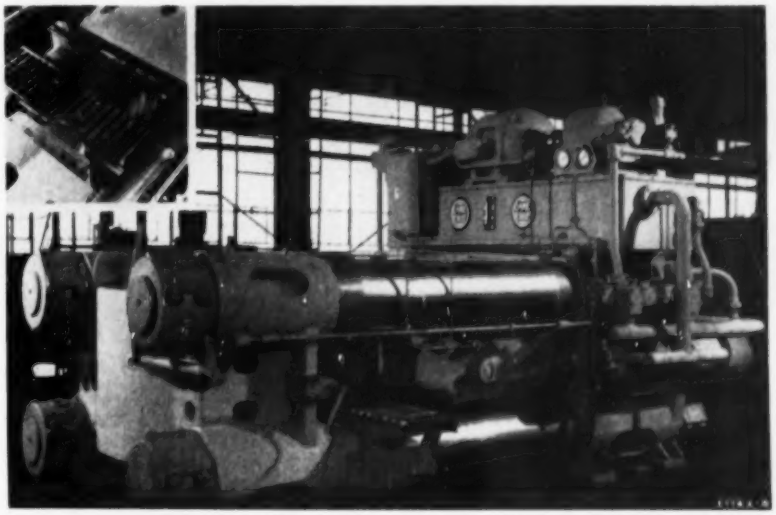
Powder Cutting

A new "Ferrojet" powder dispensing unit for powder cutting of stainless and other hard-to-cut steels is announced by National Cylinder Gas Co. This model provides greater uniform-

Heavy-Duty Billet Breaker

One of America's largest steel fabricators has installed a new Lake Erie hydraulic press for the breaking of steel billets used in the production of medium and large artillery shells. This horizontal column-type press exerts a total force up to 1500 tons, and is designed to split blooms ranging from 5 to 20 ft. in length into billets measuring from 5 to 24 in. long. The cross sections of these billets range from 5 to 12 in. square. Breaking is done by a large anvil mounted on a moving platen which is driven toward the resistance platen on which are mounted two other anvils spaced equally distant from the moving anvil.

For further information circle No. 246 on literature request card on p. 32B



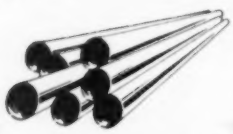
For Brass and Copper Tubing that will LAST...

Alert tubing buyers everywhere have been quick to take advantage of the savings offered by H & H METALFLO. Originated and manufactured exclusively by H & H, this BRAZED BRASS tubing can be substituted for seamless tubing wherever economy is a factor . . . whether it be in the household accessory field as illustrated above, or in the manufacture of bathroom fixtures, automotive, truck and tractor parts. So to cut *your* tubing costs, why not take this advice? For brass and copper tubing and fabricated parts that will *last*, see your nearby H & H representative *first*.

Think of

H & H

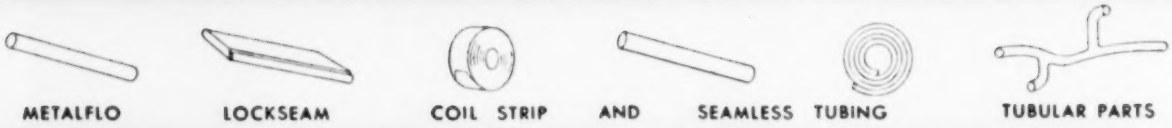
First



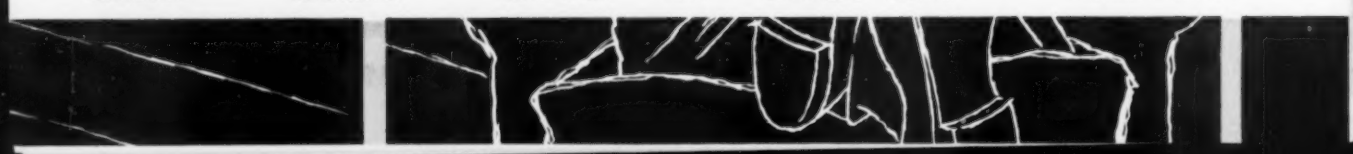
METALFLO
(BRAZED)

METALFLO is fabricated in O.D.'s of ¼" through 1¼" in wall thicknesses of .035" and lighter. It is also available in cut or random lengths, or formed to your specifications.

H&H TUBE AND MANUFACTURING COMPANY
256 North Forman Avenue, Detroit 17
Originators and sole makers of "Metalflo"—the economy tubing



METALFLO LOCKSEAM COIL STRIP AND SEAMLESS TUBING TUBULAR PARTS

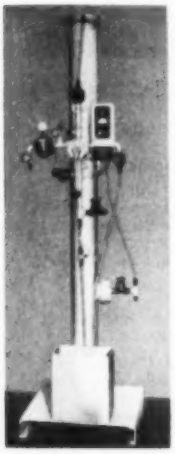


ity of powder flow as a result of improvements in the powder regulating and ejecting mechanisms. It is also portable. Gas pressure and rate of powder flow are maintained automatically by the dispensing unit. The powder control valve is also automatic, operating simultaneously with the turning on and off of the cutting oxygen valve on the torch. Machine and hand torches are available for use with dispenser.

For further information circle No. 248 on literature request card on p. 32B

Ion Exchange Demineralizer

The Penfield Mfg. Co. has announced the addition to its line of new ion-exchange demineralizers designed for users of up to 100 gal. per hr. of super-purity water. The new monocolumn demineralizer is exceptionally compact, requiring for its installation only 2 by 2 ft. of floor space. After passing only once through the monocolumn of mixed cation and anion resins, the raw water is stripped of all impurities. A flow meter on the influent enables the user to control the water intake for the most efficient ion-exchange action and an electric purity meter provides continuous indication of the purity of the demineralized water being received at the effluent.



Production of super-purity water is completely automatic, without the use of heat or steam power. Operating costs average 15 to 30 cents per 1000 gal. for mineral-free water equivalent to triple-distilled, as compared with distillation costs of $2 to $6 per 1000 gal.

For further information circle No. 249 on literature request card on p. 32B

Slack-Tube Manometer

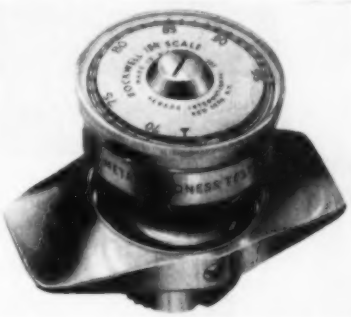
An improved Series No. 1211 flexible slack-tube manometer, equipped with

a convexed spring-steel scale for rigidity in use and flexibility for carrying, is announced by F. W. Dwyer Mfg. Co. It rolls up into a small unit to fit into pocket or service kit. It can be rolled, twisted or bent into any shape, to return to a full length U tube.

For further information circle No. 250 on literature request card on p. 32B

Portable Hardness Tester

A new Ernst tester, available through Newage International, permits metal-producing and metalworking plants to obtain superficial readings with a

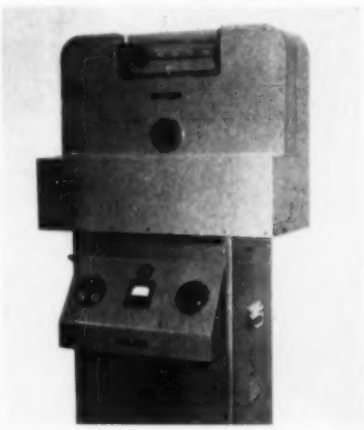


portable instrument. This hardness tester gives direct dial reading in Rockwell 15N scale over the range 70 to 95.

For further information circle No. 251 on literature request card on p. 32B

Ultrasonic Degreaser

A completely new method for fast, efficient degreasing of metal parts has been announced by the Topper Equipment Co. Heart of the new Cir-



cosonic degreaser is the General Electric ultrasonic generator. This is used in conjunction with specially developed Circo vapor degreasing equipment and technique. The ultrasonic generator converts high-frequency electrical energy into high-frequency mechanical vibration by means of a quartz crystal. This energy is transmitted up through the cleaning tank. The region above the crystal is greatly agitated, accelerating the normal cleaning action. After ultrasonic cleaning, the parts are rinsed by fresh, clean fluid and quickly dried by the vapor process.

For further information circle No. 252 on literature request card on p. 32B

Cold Treatment of Metals

Bowser Technical Refrigeration has announced a new line of units for the cold treatment of metals. The new units, with ranges from —50 to —200°

F., have several applications. Cutting-tool life can be greatly increased; distortion and cracking resulting from grinding can be eliminated; dimensions of precision parts, gages and tools can be stabilized. Cold treatment will improve expansion fitting, salvage out-of-size dies, increase hardness and lengthen the life of carburized alloy gear steels, blanking and forming dies and plastic molding dies.

For further information circle No. 253 on literature request card on p. 32B

Cutoff Press

A 35-ton press, with air-operated clutch and brake, has been announced by American Roller Die Corp. The new Ardcor press was developed as a cutoff machine in conjunction with Ardcor cold rolling mills. When the press is equipped with rails for a "flying cutoff die", a heavy-duty switch is provided on the press to operate the clutch automatically when the stock actuates the flag on the run-

out table. This same press can also be equipped with bolster plates in place of the rails and be arranged for continuous automatic operation.

For further information circle No. 254 on literature request card on p. 32B

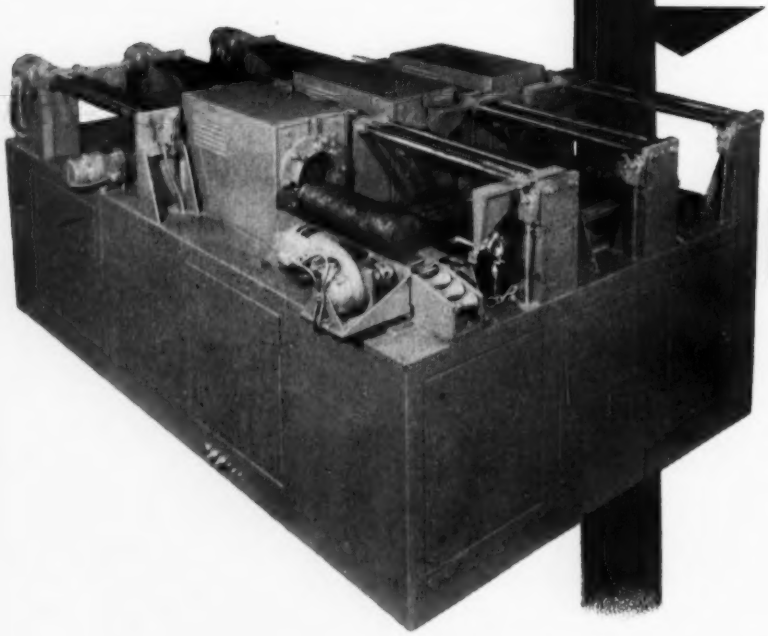
the first completely universal....

60-cycle **induction**

BILLET HEATER

THIS Loftus Universal Thermo-Induction furnace is the most flexible 60-cycle billet heater ever designed. You can heat every non-ferrous metal, in the same furnace, either consecutively or simultaneously, to its respective forging or extrusion temperature. The unit maintains high efficiency, constantly, even when heating **short-length** billets.

Loftus Thermo-Induction gives you the most practical, dependable, and efficient method of heating non-ferrous metals. You achieve uniform heating in a matter of seconds. Production is continuous, and completely automatic. The press operator controls the furnace. Separate, positive control of each coil is at his fingertips.



The Loftus 60-cycle Thermo-Induction Heater illustrated is designed to heat copper, brass, aluminum, and cupro-nickel for extrusion purposes. The unit is readily adaptable for forging and rolling processes. It is possible, with this billet heater to heat a 5" dia. Aluminum billet to 800° F., an 8" dia. brass billet to 1550° F., and a 10" dia. cupro-nickel billet to 1950° ALL AT THE SAME TIME, IN THE ONE FURNACE. Each billet is heated independently . . . from a single control panel.

Send Today for Booklet describing Loftus 60 Cycle Induction Heating in Detail

Loftus ENGINEERING CORPORATION

Designers and Builders of Industrial Furnaces

610 Smithfield Street • Pittsburgh 22, Pennsylvania

What's new

IN MANUFACTURERS' LITERATURE

280. Abrasive Wheels
Operating suggestions and recommended wheels for finishing stainless. *Manhattan Rubber Div.*

281. Alkaline Etching
Bulletin on new type of alkaline etching compound for all aluminum alloys includes case histories. *Diversey*

282. Alloy Selection
Chart to select alloy for given corrosive problem. 350 corrosives included. *Cooper Alloy Foundry*

283. Alloy Steel
32-page book on abrasion resisting steel. Properties, fabricating characteristics, uses. *U. S. Steel*

284. Alloy Steel
16-page book on type 9115 low-alloy high-strength steel. Properties, fabrication, welding. *Great Lakes Steel*

285. Alloy Steel
40-page book on heat treated alloy steel plate for maximum abrasion and impact resistance. Details on uses; 12 pp. of technical data. *Jones & Laughlin*

286. Alloy Steel
176-page bound book on hardenability, mechanical properties, heat treatment and applications of alloy steels. 28 pages of tables at end. *U. S. Steel*

287. Alloy Steel
68-page "Aircraft Steels" booklet includes revised military specifications. Also stock list. *Ryerson*

288. Alloy Steel
16-page booklet, "Alloy Steels and How to Get the Most Out of Them", contains seven case histories selected from widely varied fields. *Republic Steel*

289. Aluminum Bronze
Engineering manual on wrought forms of aluminum bronze. *Mueller Brass*

290. Aluminum Castings
Brochure "How To Cut Die-Casting Finishing Costs" deals with aluminum castings. *Monarch Aluminum*

291. Aluminum Heat Treating
8-page Bulletin 5912 on solution heat treating, annealing, stabilizing and aging of aluminum. *General Electric*

292. Aluminum Melting
8-page Notes on Aluminum deals with protecting molten aluminum, degassing and grain refining. *Foundry Services*

293. Ammonia for Heat Treat
Booklets on "Applications of Dissociated Ammonia", "Ammonia Installations for Metal Treating", "Nitriding Process", "Carbonitriding". *Armour*

294. Annealing
12-page Bulletin 5797 on electric-furnace annealing of malleable iron. *General Electric*

295. Anodizing
Data on aluminum racks with copper hooks for anodizing. *National Rack*

296. Arc Welding
Bulletin on procedure for metal arc welding of copper and copper alloys. *Krembs & Co.*

297. Atmosphere Furnaces
Information on gas-atmosphere high-production furnace for bright annealing of copper alloys. *Holcroft*

298. Atmospheres
8-page Bulletin SC-155 discusses following controlled atmospheres: RX, DX, NX, HNX, AX, HX. Compositions, applications, effects on steel, drawings of generators. *Surface Combustion*

299. Barrel Finishing
22-page book on single-unit installation to yield savings up to 95% in finishing various parts. *Almco Div.*

300. Barrel Plating
Bulletin PB108 on submerged barrel plating. *Hanson-Van Winkle-Munning*

301. Barrel Plating
Folder on barrel plating with unique contact arrangement for maximum current distribution. *Daniels*

309. Brazing
Free sample of silver brazing-alloy preformed washer coined from wire. *Lucas-Milhaupt Engineering*

310. Brazing
50-page text GEA-3193 describes the methods and applications of electric-furnace brazing. *General Electric*

311. Brazing and Annealing
Bulletin on high speed heating for brazing, flame annealing, flame hardening, selective heating, and heating for forming. *Gas Appliance Service*

312. Brazing Applications
48-page manual on all aspects of silver brazing applications and problems. *American Platinum Works*

313. Brazing Stainless Steel
Illustrated booklet, "Bright Annealing, Hardening and Brazing Stainless Steel". *Sargeant & Wilbur*

314. Brazing Titanium
Data sheet on use of a new flux for brazing titanium. *Handy & Harman*

487. Pickling

A book that has served its industry for 29 years merits more than passing mention. Such a publication is the 80-page book, "Efficient Pickling",* which is now available in a new fifth edition, the first revision of the material in eight years. This publication is directed to every metals engineer who has a scale-removal problem or a job of surface preparation.

There are countless variations to the pickling process. In all of them, the central problem is to get all the scale off the metal (in this book, ferrous metal) as efficiently as possible and to leave the metal undisturbed. A very high percentage of pickling operations involve an inhibitor or "pickle control" ingredient which is added to prevent the acid from dissolving the metal and pitting it. Such additives are amply discussed and net savings from their use are indicated.

Efficiency and economy of pickling depend on acid and inhibitor concentrations, temperature, time, agitation and other variables. The text, graphs and charts of this book will be of value in finding the optimum combination of variables. Especially helpful will be the recommended record forms – pickle logs – which are illustrated.

All the details of pickling are covered, including pickle bath test procedures. The final section of the book suggests proper practices for pickling various types of products – billets, alloy steel forgings, seamless tubing, pipe for enameling, wire rods, narrow strip, cold drawn bars, galvanized sheets, tin plate, castings, machined steel parts, stainless steel and others. A ten-page appendix of tables summarizes much of the information presented in the text.

*Published by American Chemical Paint Co. Copies are available at no charge to readers of Metal Progress who circle No. 487 on the request card, page 32B.

302. Bimetal Applications
64-page book on application of thermostatic bimetal. Property charts for 30 types. Design formulas. *W. M. Chace*

303. Black Oxide Finish
Four-page article "Low-Cost Black Oxide Finish on Steel by Chemical Dip Method". *Mitchell-Bradford*

304. Blackening Compounds
Bulletin on blackening compounds (for ferrous alloys) to AMS Spec. 2485. *Swift Industrial Chemical*

305. Blackening Copper
Bulletin of operating instructions for blackening and coloring copper and copper alloys. *Enthone*

306. Blast Cleaning
24-page Bulletin 400 on blast cleaning installations for large work. *Pangborn*

307. Blast Cleaning
12-page bulletin on 6 and 12 cu.ft. machines for blast cleaning. *Pangborn*

308. Brass Foundry
Article discusses fume control in brass foundry. 8 sketches of installations. *R. Lavin & Sons*

315. Bronze Electrode
Data sheet on phosphor bronze arc welding electrode for phosphor and manganese bronzes. *Weldwire*

316. Bronzes
Folder gives tables of properties (hardness, tensile, fabrication, physical) as well as uses and forms and other data on phosphor bronzes. *Chase Brass*

317. Buffing Calculator
See review on page 25. *American Buff*

318. Burners
Bulletin on combination gas and oil burner. *Ra-Diant Products*

319. Burners
16-page Bulletin 1220 on long-flame burners, gas, oil, or gas and oil. *Bloom*

320. Burners
16-page bulletin on selection of gas burners. *Western Products*

321. Calrod Heaters
16-page Bulletin 5866 gives 14 case histories on use of electric heating elements. *General Electric*

322. Carbide Segregation
Effect of carbide segregation in tool steel. *Latrobe Steel*

323. Carbide Tools
48-page catalog on carbide tools. *Nelco Tool*

324. Carbon Control
Catalog T-623 describes the Microcarb control system that continuously measures the active carbon in the furnace atmosphere during heat treatment. *Leeds & Northrup*

325. Carbon Control
Technical report on instrument for control of carbon potential of furnace atmospheres. *Lindberg Engineering*

326. Carbon Steel Castings
Data folders on four types of carbon steel castings. Composition, properties, hardenability bands, uses. *Unitcast*

327. Carbonitriding
Literature on Ni-Carb (carbonitriding) treatment for surface hardening. *American Gas Furnace*

328. Carburizing
Data folder on Aerocarb E and W water-soluble compounds for liquid carburizing. Case depth vs. time curves. Per cent carbon and nitrogen penetration curves. *American Cyanamid*

329. Cast Iron
38-page brochure on gray iron casting procedures and products. *American Car and Foundry*

330. Castings, Bronze
16-page booklet on sand and centrifugal castings. *Amer. Non-Gran Bronze*

331. Chromate Coatings
Folder gives characteristics and uses of chromate conversion coatings on nonferrous metals. *Allied Research*

332. Chromium Stainless
12-page book on fabrication and use of Type 430 stainless steel. *Sharon Steel*

333. Chromium Stainless
12-page book, "Type 430 Stainless Steels as Alternates of the 18-8 Series". Fabrication data, four pages of comparative corrosion ratings for Types 430, 302 and 316. *Republic Steel*

334. Cleaner
Folder gives data on metal cleaners for use with water in still-tank or spray-washing equipment. *Solventol*

335. Cleaning
12-page bulletin on washing and drying machines; conveyor, cabinet, drum and vertical types. *Industrial Systems*

336. Cleaning
20-page bulletin 214 gives performance on Rotoblast cleaning. *Pangborn*

337. Cleaning
Bulletin on equipment for cleaning and pickling of shell cases and other ordnance items. *Alvey-Ferguson*

338. Cleaning Equipment
Folder on degreaser. Data on different models. *Topper Equipment*

339. Cleaning Equipment and Materials
Series of attractively illustrated bulletins informs concerning dry cleaning process, degreasers, metal parts washers, degreasing solvents, emulsion and alkaline cleaners and rust-proofing compounds. *Detrex Corp.*

340. Cleaning Stainless
8-page booklet on care and cleaning of stainless steels. *Republic Steel*

341. CO_2 as Coolant
Bulletin on use of a jet of liquid carbon dioxide directed at point of contact between cutting tool and work to keep both cool. *Pure Carbonic Co.*

342. Cobalt Alloy
12-page booklet, "Haynes Alloy No. 25", tells of the unique properties of this cobalt-base alloy. *Haynes Stellite*

343. Cold Finished Bars
Engineering bulletin, "New Economies in the Use of Steel Bars". *LaSalle Steel*

344. Cold Steel Extrusion
Bulletin on commercial applications of Koldflo process for steel. *Mullins Mfg.*

345. Combustion Control
20-page booklet presents combustion charts for various fuels and describes portable instrument which measures content of oxygen and combustibles simultaneously. *Cities Service Oil*

346. Combustion Safeguard
Bulletin 9602 on flame-failure protection for any fuel-fired furnace. *Minneapolis-Honeywell*

347. Continuous Furnaces
Bulletin 160 on roller hearth furnaces. Controlled atmosphere, direct fired and convection heated. *Surface Combustion*

348. Controlled Atmospheres
24-page bulletin describes production problems with reference to dry atmospheres. *Pittsburgh Lectrodryer*

317. Buffing Calculator

Slide-rule-type device answers questions such as: What type of buff is required for polishing aluminum die castings? What diameter wheel produces a certain surface speed? The calculator aids in selection of correct buff, size and speed for each job. *American Buff Co.*

349. Copper Alloy Tubes
32-page brochure on causes of corrosion and means of combating them. Choice of materials for condenser tubes. *Revere Copper & Brass*

350. Core Baking
16-page bulletin on electronic equipment for foundry core baking. *Induction Heating Corp.*

351. Corrosion of Copper
24-page booklet B-36 discusses corrosive attack on copper and copper alloys. Tabulation of their relative corrosion resistance. *American Brass*

352. Corrosion-Proof Cement
Bulletin gives corrosion resistance of four types of cement vs. 176 chemical solutions. *Atlas Mineral Products*

353. Crystal Models
Folder describes unique kit for constructing crystal models. *Harshaw*

354. Cutting Oil
Shop Notebook gives important facts on right cutting fluid for any machining operation. *D. A. Stuart*

355. Cutting Oil System
Data and charts on new cutting oil, dispensing jet and motor-driven pump. Test results of overhead flood with conventional coolants vs. jet. *Gulf Oil*

356. Definitions
36-page glossary of over 150 terms on cast iron. *International Nickel*

357. Degreasing
Pamphlet on properties and use of trichlorethylene. *Niagara Alkali*

358. Degreasing
24-page brochure on medium-pH cleaner to follow solvent degreasing or other precleaner. *Northwest Chemical*

359. Descaling Process
8-page bulletin on sodium hydride descaling process for ferrous and nonferrous metals. *Du Pont*

360. Desulphurization
12-page "Desulphurizing Molten Metal With Dense Soda Ash", of special interest to foundrymen. *Solvay Process Div.*

361. Die-Casting Machines
Illustrated booklet giving specifications, application data and full explanations of two new production advantages on company's line of die-casting machines. *Lake Erie Engineering*

362. Die Castings
Bulletin on design and manufacture of aluminum die castings. *Hoover Co.*

363. Drawing Compounds
Folder on lubricant for forming and drawing of stainless. *Hangsterfer*

364. Edge Position Control
4-page Bulletin 141 on method for controlling edge position of a moving strip of metal or other material. *Askania Regulator*

365. Electric Melting
Series of three bulletins on induction furnaces for melting ferrous and nonferrous metals. Data on capacity and power consumption for different alloys. *Russ Electric Furnace*

366. Electric Melting
Bulletin 527 on compact arc furnace. Melt time and power consumption for four alloys. *Detroit Electric Furnace*

367. Electropolisher
Bulletin on theory and practice of electrolytic polishing of metallurgical samples. Description of electropolisher. *Buehler, Ltd.*

368. Fabricating Machinery
16-page technical bulletin on special-purpose metalworking machinery for ferrous and nonferrous. *H. W. North Co.*

369. Fabrication Data File
Reference file of engineering information about equipment and processes used for stampings, heavy weldments and pressed steel shapes. *Brandt*

370. Ferro-Alloys
64-page book describes over 50 metals and alloys produced by company. *Electro Metallurgical*

371. Finishing
Catalog A-653 gives complete story on planning industrial finishing systems and shows many installations of cleaning and pickling machines. *R. C. Mahon*

372. Finishing
Six bulletins describing finishing compounds for stainless steel, aluminum, other metals. *Apothecaries Hall*

373. Finishing Fixtures
28-page catalog B-9 on corrosion-resistant baskets, racks, crates and tanks and other fixtures for cleaning and finishing. *Rolock*

374. Finishing Systems
Bulletin on cleaning and rust-proofing equipment, spray booths and drying ovens. *Peters-Dalton*

375. Flame Hardening
12-page bulletin on flame-hardening machines for automatic gear hardening, crankshaft hardening and bolt hardening. *Carlinho Commodities Corp.*

NEW ACCURACY
NEW TOUGHNESS
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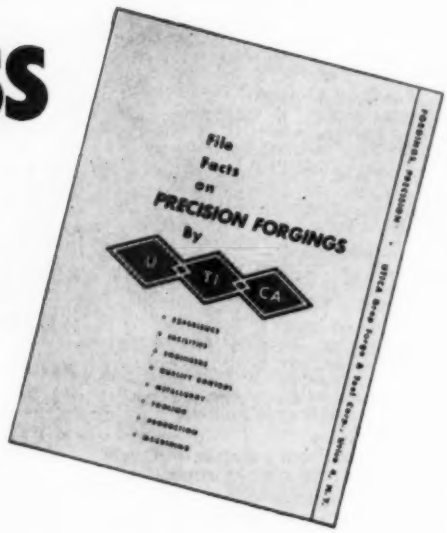

Our new data folder, available upon request, brings the details to you.

Utica is now forging small parts accurate to within a very few thousandths.

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400,000 square feet of UTICA plant–die shops, forge shops, finishing operations – are tooled to produce any conceivable forged shape. Millers, grinders, all types of forges, presses, upsetting machines, furnaces, heaters, sandblasters, broaches, polishers unite in efficient production of complicated parts.

New methods, and new machines as well, spring from UTICA's policy of "going heavy" on engineering skill. They are natural results of a cost-minded, progressive approach to the handling of each job on an individual basis.

Hard-to-handle metals are a specialty of the Metallurgical Department. Backed by a 10,000 sq. ft. laboratory with the latest physical testing and metallographic equipment, metallurgists are the "watchdogs" of all UTICA products.

Quality Control on irregular shaped parts is a familiar problem. Dimensional readings plus visual inspection plus statistical control are all in full use.

Jet blade production, an exacting new field requiring true pioneering, has absorbed the major part of UTICA facilities. But the problems are similar, if less complicated, in other cases where special accuracy and toughness in parts are needed.

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376. Flaw Detection
Information on electronic equipment for nondestructive inspection of regular and irregular iron and steel parts. *Magnetic Analysis Corp. (Foerster)*

377. Flaw Detection
12-page bulletin on location of flaws by two dye-penetrant inspection methods. *Turco Products*

378. Flow Control
24-page Bulletin 139 on controls for pressure and flow of liquids and gases. Details on proportioning control. *Askania Regulator*

379. Flow Meters
Bulletin 201 on flow meter for gas used in heat treating. *Waukee Engineering*

380. Flow Meters
Catalog on meters and accessories for measuring pressure and vacuum of liquids and gases. *Meriam Instrument*

381. Forging Manipulators
Folder on manipulators for automotive, ordnance, aluminum and specialty forging. *Salem-Brosius*

382. Forgings
Handsome 32-page brochure on large forgings for turbine shafts, rotors, drop hammer anvils, rolls. *U. S. Steel*

383. Forgings
20-page Catalog 51 on various types of forgings, their strength and related data. Tables, drawings. *Merrill Bros.*

384. Forming Dies
Data on roller dies for forming tubes and rolled shapes. *American Roller Die*

385. Foundry Coatings
Data on colloidal graphite for mold washes, pattern coatings, core coatings, chill coatings. *Acheson Colloids*

386. Foundry Practice
Article on gates and risers with reference to nonferrous practice. *R. Lavin*

387. Foundry Wash
Bulletin on zirconite all-purpose paste wash for foundry applications. *Titanium Alloy Mfg.*

388. Furnace Controls
Bulletin on instruments and controls for heat treating furnaces. *Hays Corp.*

389. Furnace Fixtures
16-page catalog on baskets, trays, fixtures and carburizing boxes for heat treating. 66 designs. *Stanwood Corp.*

390. Furnaces
Bulletin describes 18 electric furnaces for research and small-scale production, with operating temperatures to 3000 F. *Harper Electric Furnace*

391. Furnaces
44-page Catalog 112, well illustrated, features furnaces for hardening, tempering, carbonitriding, forge heating, sintering, annealing and tool heat treating. Also atmosphere generators and ammonia dissociators. *C. I. Hayes*

392. Furnaces
40-page book describes gas and electric furnaces and applications. Four basic types of atmospheres. Glossary of heat treating terms. *Westinghouse*

393. Furnaces, Annealing
Folder of performance and cost data on radiant tube and roller hearth furnaces. *Gas Machinery*

394. Furnaces, Atmosphere
Bulletin F-1 on versatile, controlled-atmosphere furnace for all steels from high carbon to high speed in range 1200 to 2800 F. *Delaware Tool Steel*

395. Furnaces, Heat Treating
12-page bulletin on conveyor furnace, radiant tube gas heated, oil or electrically heated. *Electric Furnace Co.*

396. Furnaces, Heat Treating
Bulletin on furnaces for annealing, normalizing, hardening, tempering, forging. *Flinn & Dreffein Engineering*

397. Furnaces, Heat Treating
Catalog on furnaces for tool room and general-purpose heat treat. *Cooley*

398. Furnaces, Heat Treating
Bulletin on fuel and electric furnaces for heat treating. *Dempsey*

399. Furnaces, Heat Treating
Bulletin 850 on shaker-hearth furnace for bright carburizing, carbonitriding, hardening. *Hevi Duty Electric*

400. Furnaces, Heat Treating
32-page catalog on high-speed gas furnaces for heat treating carbon and alloy steels; also pot furnaces for salt and lead hardening. *Charles A. Hones*

401. Galvanizing
Reprint "Modern Hot-Dip Galvanizing" deals with dross formation as a cause of zinc waste. Detailed information on zinc ammonium chloride type of flux. *Hanson-Van Winkle-Munning*

402. Gas Analysis
60-page book on theory of gas analysis, procedures, maintenance and operation of equipment. *Fisher Scientific*

403. Gas Flow Meter
Bulletin on gas flow meter for furnace installations. *Hays Corp.*

404. Graphite Electrodes
164-page vest-pocket data book on graphite electrodes and electric-arc furnace practice. *International Graphite*

405. Hardening Control
Bulletin on instrument for controlling flame hardening and other applications. *Carlingo Commodities Corp.*

406. Hardness Numbers
Pocket-size table of Brinell hardness numbers, incorporating other tabular information of importance to the metallurgist, inspector and engineer. *Steel City Testing*

407. Hardness Tester
20-page book on machine for hardness testing by Rockwell method. *Clark Instrument*

408. Hardness Tester
Bulletin on testing by Rockwell method of large or odd-shaped specimens with unique clamping method. *Testing Equipment Co.*

409. Hardness Tester
Bulletin on Impressor portable hardness tester. *Barber-Colman*

410. Hardness Tester
Literature on Brinell testing machines. *Detroit Testing Machine Co.*

411. Hardness Tester
Bulletin ET 407 on new portable hardness tester. *Newage International*

412. Hardness Tester
4-page bulletin on Brinell hardness tester weighing 26 lbs. for portable and stationary use. *Andrew King*

413. Heat Resistant Gloves
12-page catalog of heat and flame resistant gloves for heat treating and welding operators. *C. Walker Jones Co.*

414. Heat Treating
72-page catalog on carburizing, cyaniding, brazing, austempering and annealing processes. *Ajax Electric*

415. Heat Treating
Bulletin 120 on use of heat exchangers to provide heat control in quenching bath. *Niagara Blower*

416. Heat Treating
Bulletin T-19 on forced convection furnaces for heat treating in controlled atmosphere. *Ipsen*

417. Heat Treating
12-page bulletin on heat treating in a steam atmosphere. *Leeds & Northrup*

418. Heat Treating
Booklet describes facilities for heat treating steel, aluminum and magnesium. *Pearson Industrial Steel Treating*

419. Heat Treating Aluminum
Bulletin 14-T on ovens for heat treatment of aluminum and other low-temperature processing. *Young Bros.*

420. Heat Treating Belts
44-page catalog describes metal belts for quenching, tempering, carburizing and other applications. *Ashworth Bros.*

421. Heat Treatment of Pipe
Reprint on continuous hardening of steel pipe. *Selas*

422. Heating Elements
24-page Bulletin H on electric heating elements. Includes extensive tabular data on physical and electrical specifications for various sizes. *Globar Div.*

423. Heating Equipment
Bulletin, "Make Your Own Gas", describes generator to convert oil to gas for standby or primary fuel. *Vapofier*

424. Heating Steel Rounds
8-page reprint on high-temperature fast heating of steel rounds. *Selas*

425. Heavy-Duty Cleaning
Booklet on LP cleaner for all metals except aluminum. *Cowles*

426. Heliarc Welding
Pocket-sized folder contains current ranges and sizes for electrodes with table on current and number of passes required to weld various metals. *Linde*

427. High-Alloy Castings
28-page "Ni-Cr Castings to Resist Heat & Corrosion". *Standard Alloy*

428. High-Temperature Alloy
Bulletin describes "Incoloy", new nickel-chromium alloy for high temperature and corrosive environments. *International Nickel*

429. High-Temperature Alloy
Property data for 21% Cr, 9% Ni heat-resistant alloy. *Electro-Alloys Div.*

430. Hole Punching
32-page Catalog BL on equipment for punching mild steel up to ⅝ in. thick. *Wales-Strippit*

431. Hydraulic Presses
Bulletin 147, "Practical Facts About Hydraulic Presses", an informative guide for the user of all types and sizes of hydraulic presses. *Lake Erie Engineering Corp.*

432. Impact Forming
16-page bulletin on new process for automatic mechanical production of impact die forgings. *Chambersburg Engineering*

433. Induction Heating
Book contains selector chart and heating and melting speeds for induction equipment. *Ajax Electrothermic*

434. Induction Heating
12-page bulletin 5679 on induction hardening, brazing, annealing at 1000, 3000, and 10,000 cycles. *General Electric*

435. Induction Heating
Catalog MP-2 describes portable high frequency induction heating unit for brazing, hardening, soldering, annealing and melting. *Lepel High Frequency*

436. Induction Heating
Bulletin on new 60-cycle induction furnace for heating aluminum, magnesium, copper and brass for forging, extrusion and rolling. *Loftus Engineering*

437. Induction Heating
Bulletin on low-frequency (60 cycle) induction heating furnace for nonferrous metals. *Magnethermic*

438. Induction Heating
60-page catalog tells of reduced cost and increased speed of production on hardening, brazing, annealing, forging or melting jobs. *Ohio Crankshaft*

439. Induction Heating
"Induction Heating" . . . presents case histories of increased production, reduced space, lower costs. *Westinghouse*

REQUIRE PRECISE TEMPERATURE CONTROL?

Thermo Electronic TEMPERATURE CONTROLLERS

provide
NULL BALANCE ACCURACY
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AND SPEED

AT LOW COST

Now, with Thermo Electronic Controllers, thermocouple and resistance bulb types, you can afford accurate, automatic temperature control on processes and equipment operating between −100°F and 3000°F. The two-position control action is continuous and high speed, only one part—a magnetic control relay—moves positively when the process calls for a change of heat. Both types of controllers incorporate a null balance circuit for high measuring accuracy with an electronic control system for sensitivity and speed. Calibration is guaranteed to within plus or minus ¼ of 1% of full scale range. Bright signal lights indicate temperature conditions and are clearly visible over wide angles and great distances.

Outstanding features of Thermo Electronic Controllers are simplicity of design and sturdy and compact construction. They are easy to install, economical to operate, and require little maintenance. Severe vibration or mechanical shock will not affect the measuring accuracy or control sensitivity.

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Thermocouple Pyrometer Controller Bulletin 50H
Resistance Bulb Controller Bulletin 55H

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Quick Coupling Connectors
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Resistance Bulbs
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FAIR LAWN NEW JERSEY

440. Induction Heating
Bulletin on new-design tube for induction and dielectric heating. *Federal Telephone & Radio*

441. Induction Heating
Data folder on megacycle tube-type machines for soldering, brazing, hardening. *Sherman Industrial Electronics*

442. Induction Melting
8-page article describes use of induction melting in improved technique for rotor-casting. *Ajax Engineering*

443. Industrial Planning
Book 127 on planning expansion, remodeling or modernization of plant. *Continental Industrial Engineers*

444. Inert-Arc Welding
Bulletin on material for eliminating porosity problems in inert-arc welding of rimmed steel. *Spekaluminite*

445. Inert-Gas Welding
Heliwelding, inert-gas-shielded arc-welding process for all-position welding of aluminum, magnesium, stainless steel, brass and copper, in ADC-709, Catalog 9. *Air Reduction*

446. Inspection
8-page bulletin on optical equipment and accessories for inspection. *Arthur S. LaPine & Co.*

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Article gives case histories on martempering of aircraft gears. *Ajax Electric*

466. Martempering
Job data on martempering of chain links. *Ipsen*

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26-page Bulletin 41 on application of Meehanite for forming and stamping dies. *Meehanite Metal Corp.*

468. Melting
24-page book on electric furnaces for steel mills and foundries. Table of types, sizes, ratings. *American Bridge*

469. Melting Aluminum
Bulletin 310 on furnaces for melting aluminum. *Lindberg Engineering*

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Research metallograph, described in catalog E-240, furnishes four different accurate images of same sample for complete identification with bright field, dark field or polarized light. *Bausch & Lomb*

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Bulletin describes the Kentron microhardness tester. *Kent Cliff Laboratories*

473. Microhardness Tester
Bulletin DH-114 on Tukon hardness testers in research and industrial testing. *Wilson Mechanical Instrument*

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40-page booklet on Moly-sulphide lubricant gives case histories for 154 different uses. *Climax Molybdenum*

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Booklet on properties and applications of cast Monel. *Cooper Alloy Foundry*

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28-page Bulletin 646 on carburizing and nitriding furnace giving atmosphere circulation to 1850° F. *Hevi Duty*

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12-page bulletin on eight types of gas furnaces for melting nonferrous metals. *Bellevue Industrial Furnace*

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Bulletin on mechanically-operated induction furnace for precision casting. *Ajax Electrothermic*

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Bulletin 706 on the Mercast frozen mercury process of investment casting. *Alloy Precision Castings*

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Bulletin 5212 on small dry-abrasive airblast unit for cutting hard materials and precision finishing. *S. S. White*

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Buyers' Guide for pyrometer supplies, No. 100-4. *Minneapolis-Honeywell*

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12-page Bulletin 713 on indicating and controlling pyrometers. Functional diagrams of installations. *Gen. Electric*

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8-page bulletin on continuous quench tank conveyor. *Klaas Machine & Mfg.*

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Bulletin on reasons for quenching oil failure and maintenance of quenching systems. *Industrial Filtration Co.*

509. Quenching
"Handbook on Quenching" gives complete information. *E. F. Houghton*

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Bulletin on machine for quenching die holes in case hardening. *Palmer Mfg.*

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Technical bulletin F-8 on quenching oil and accelerators to provide deeper hardening. *Park Chemical Co.*

512. Radiography
Bulletin 400-310 on self-contained X-ray unit for mass production inspection of parts. *Westinghouse*

513. Radiography
34-page book on X-ray applications features radiography of castings and weldments. *X-Ray Dept., Gen. Electric*

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16-page Bulletin 81 describes and illustrates heat treating furnaces for ferrous and nonferrous parts and other heat treat equipment. *Despatch Oven*

515. Recorder Controllers
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516. Reference Data
8-page booklet of hardness and temperature conversions, weights of bars, other data. *Milne*

517. Refractories
Form 1409 on fused stabilized zirconia refractory for furnace linings, metal melting, other uses. *Norton Co.*

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20-page booklet gives technical information on super refractories. Charts, tables and application data. *Refractories Div., Carborundum Co.*

520. Refractories
12-page brochure on products for casting special refractory shapes and for gunning and troweling applications, for services to 3000° F. *Johns-Manville*

521. Refractory Mixes
16-page bulletin 315 on properties and applications of sillimanite superrefractory ramming mixes and furnace patches. *Chas. Taylor Sons*

522. Rhodium Plating
Directions for rhodium plating, with reference to use as replacement for usual plating metals. *Baker & Co.*

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Data Sheet 522 on four materials of promise for rocket nozzles. *Norton Co.*

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Literature on rust-proofing ferrous metal parts. *American Chemical Paint*

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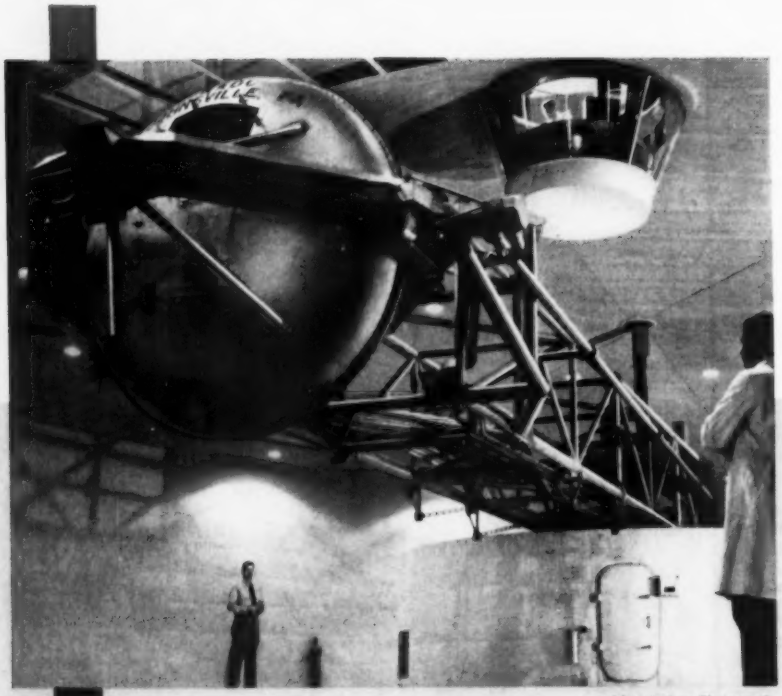
Data sheet 5.2-5 describes instrumentation for temperature control of salt baths in heat treatment of high speed steel. *Minneapolis-Honeywell*

(Continued on page 32-A)



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(*Continued from page 31*)

527. Salt Bath Descaling
12-page bulletin B-40 describes continuous and batch descaling lines for removing oxide from steel, bronze, copper, stainless and titanium. *Drever*

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Data on salt bath furnaces for batch and conveyorized work. *Upton*

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20-page book on specific applications of stainless steel in the pulp and paper industry. *Crucible Steel*

551. Stainless Steel
Data sheet on wrought alloy type 330, 35% Ni – 15% Cr. Mechanical properties of bars to 1800° F.; design stresses to 2100° F. *Rolled Alloys, Inc.*

552. Stainless Steel
16-page "Type 430 Stainless for Architects and Designers". *Washington Steel*

553. Stainless Steel
32-page book on corrosion resistance of stainless steels. 18 tables on tests in acid, neutral and alkaline solutions. *International Nickel*

554. Stainless Steel
Slide chart. Set top at a certain fabricating operation, bottom shows rating of each standard grade. On reverse side, heat treating and corrosion data are given. *Carpenter Steel*

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20-page book on uses of stainless steels. *Electro Metallurgical*

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6-page reprint "Tips on Stainless for Aircraft Hydraulics". Design and fabrication. *Superior Tube*

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585. Tin
16-page article "Tin Conservation", from Journal of American Society of Naval Engineers. *Code 350, U. S. Navy*

586. Tin
Monthly newsletter, "Tin News", gives information about prices, supply, demand. *Malayan Tin Bureau*

587. Titanium
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72-page catalog on film-processing tanks and systems, darkroom accessories, X-ray protection materials. *Bar-Ray Products*

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104-page catalog of X-ray supplies for industrial radiography. *Keleket*

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242	267	292	317	342	367	392	417	442	467	492	517	542	567	592
243	268	293	318	343	368	393	418	443	468	493	518	543	568	593
244	269	294	319	344	369	394	419	444	469	494	519	544	569	594
245	270	295	320	345	370	395	420	445	470	495	520	545	570	595
246	271	296	321	346	371	396	421	446	471	496	521	546	571	596
247	272	297	322	347	372	397	422	447	472	497	522	547	572	597
248	273	298	323	348	373	398	423	448	473	498	523	548	573	598
249	274	299	324	349	374	399	424	449	474	499	524	549	574	599
250	275	300	325	350	375	400	425	450	475	500	525	550	575	600
251	276	301	326	351	376	401	426	451	476	501	526	551	576	601
252	277	302	327	352	377	402	427	452	477	502	527	552	577	602
253	278	303	328	353	378	403	428	453	478	503	528	553	578	603
254	279	304	329	354	379	404	429	454	479	504	529	554	579	604
255	280	305	330	355	380	405	430	455	480	505	530	555	580	605
256	281	306	331	356	381	406	431	456	481	506	531	556	581	606
257	282	307	332	357	382	407	432	457	482	507	532	557	582	607
258	283	308	333	358	383	408	433	458	483	508	533	558	583	608
259	284	309	334	359	384	409	434	459	484	509	534	559	584	609
260	285	310	335	360	385	410	435	460	485	510	535	560	585	610
261	286	311	336	361	386	411	436	461	486	511	536	561	586	
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263	288	313	338	363	388	413	438	463	488	513	538	563	588	
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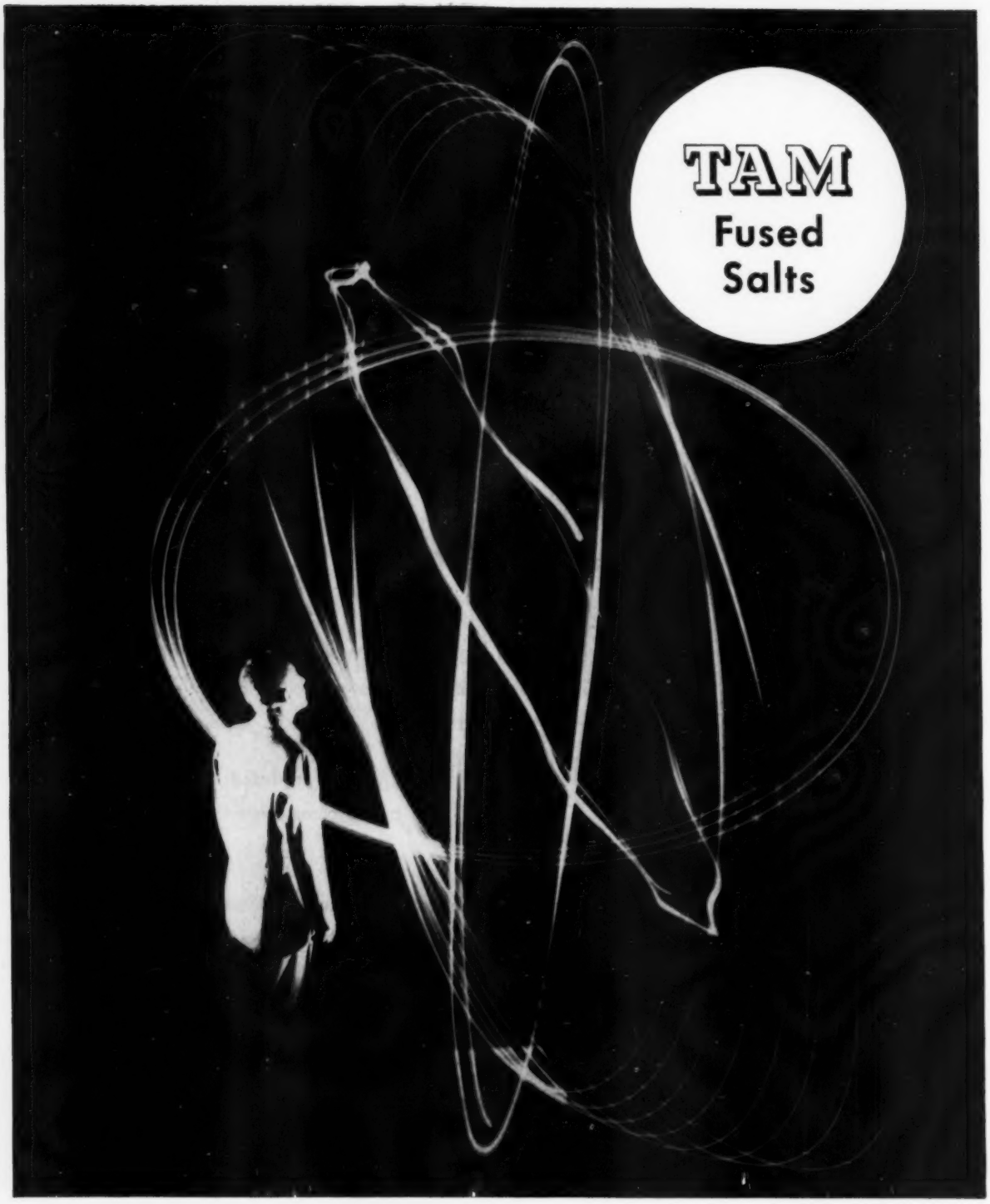

HAVE YOU INVESTIGATED THE ADVANTAGES OF TAM FUSED SALTS RECENTLY?

These TAM products are finding increasingly successful use as a source of zirconium for magnesium alloys. By refining grain size, they help improve strength in castings and eliminate problems in extruding bars. Ask our field engineers for details or write us at New York.

*TAM is a registered trademark.

TAM PRODUCTS
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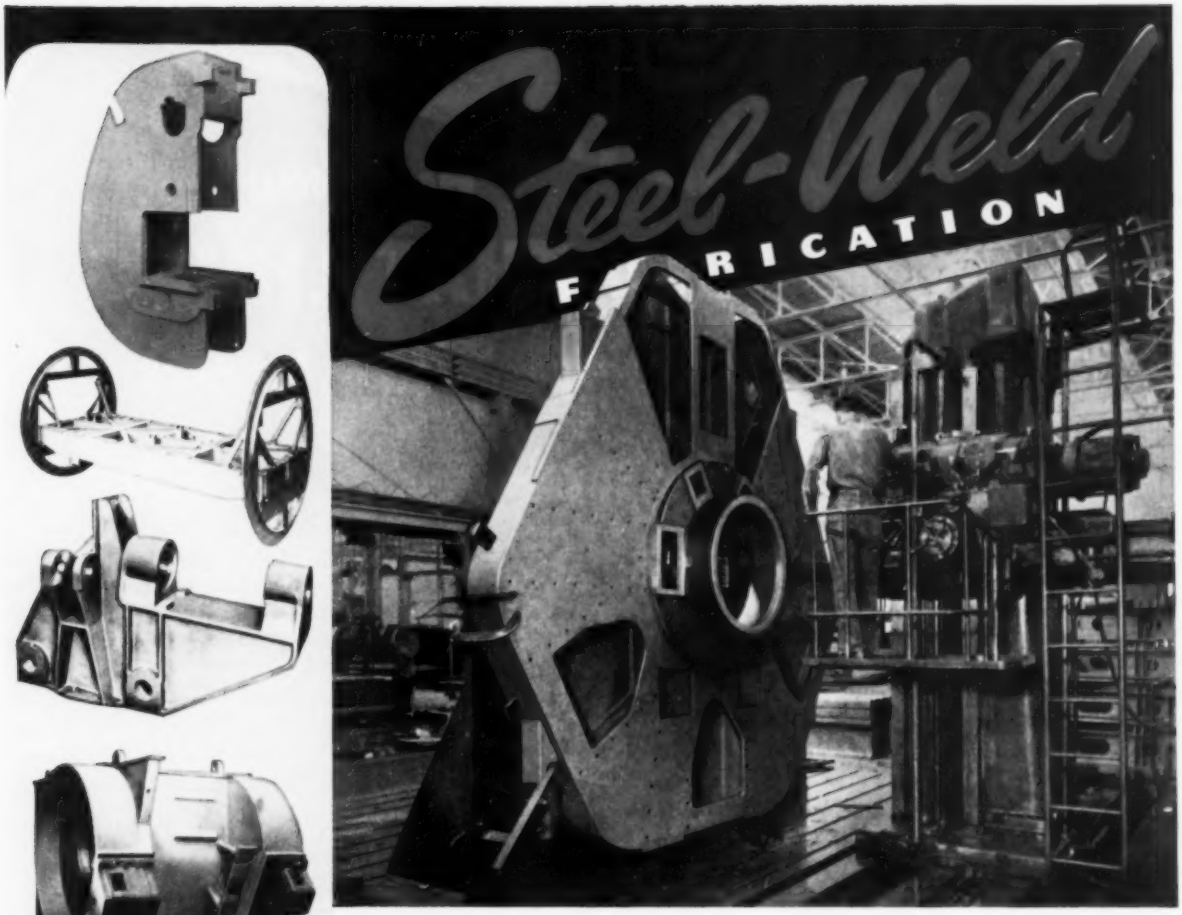
TITANIUM ALLOY MFG. DIVISION
NATIONAL LEAD COMPANY

Executive and Sales Offices: 111 BROADWAY, NEW YORK CITY
General Offices, Works and Research Laboratories: NIAGARA FALLS, N. Y.



Use WELDED STEEL
for Greater Strength
with Less Weight!

Above is another excellent example of Mahon versatility in the production of Steel-Weld Fabricated units for many industries. This base, undergoing machining operations, was produced for a TV picture tube manufacturer in the glass Industry...it is typical of thousands of Steel-Weld Fabricated parts and assemblies produced and machined by the Mahon Company for manufacturers throughout the country. If parts or assemblies in your product could be redesigned and produced to better advantage through Steel-Weld Fabrication, or, if you are faced with a limited production of a product involving heavy pieces in which pattern costs are a consideration, you can turn to Mahon with complete confidence. You will find in the Mahon organization a unique source with complete, modern fabricating, machining and handling equipment to cope with any type of work regardless of size or weight . . . a source where skillful designing and advanced fabricating technique are supplemented by craftsmanship which assures you a smoother, finer appearing job, embodying every advantage of Steel-Weld Fabrication.

THE R. C. MAHON COMPANY
DETROIT 34, MICHIGAN

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

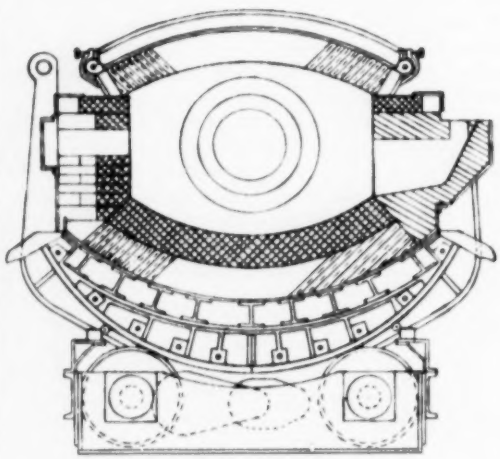
Here's how to HOLD THAT LINING in your holding furnace

Operators of Whiting* Cradle and similar types of holding furnaces use Taylor Sillimanite (TASIL) brick and cement to prolong the life of refractory linings. Recommended practice is to "*balance*" the super-duty fire brick lining with 9" of TASIL brick, laid in TASIL No. 301 Cement, for both side walls and bottom, in the areas subject to the damaging wash of molten iron and slag. (See refractory construction shown in engineering drawings below.)

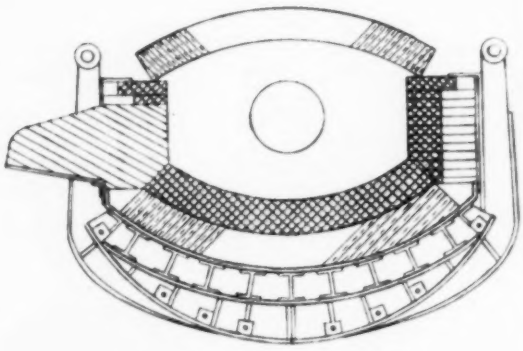
A TASIL "balanced" lining at one plant is averaging 6-8 weeks on side walls and 9-12 months on bottoms, with patching. TASIL was tried after a super-duty fire brick lining failed in three days because of joint attack and severe erosion at the metal line. This furnace is fired with pulverized coal and runs 700 tons per week of grey iron, tapped from cupola at 2750° to 2800° F.

Wherever you use fireclay-base, high alumina, kaolin or similar refractories, TASIL will give more effective service. Let a Taylor field engineer discuss with you the savings Taylor Sillimanite can make in your plant.

Tasil "Balanced" Lining In Whiting Cradle Furnace



Section through Pour-in Spout



Section through Pour-out Spout

TASIL sidewalls and bottom 9" thick. TASIL top course in sidewall 13½" thick.

= Taylor Sillimanite

* Built by Whiting Corporation, Harvey, Ill.

Exclusive Agents in Canada:
REFRACTORIES ENGINEERING AND SUPPLIES, LTD.
Hamilton and Montreal

The **CHAS. TAYLOR SONS Co.**
A SUBSIDIARY OF NATIONAL LEAD COMPANY
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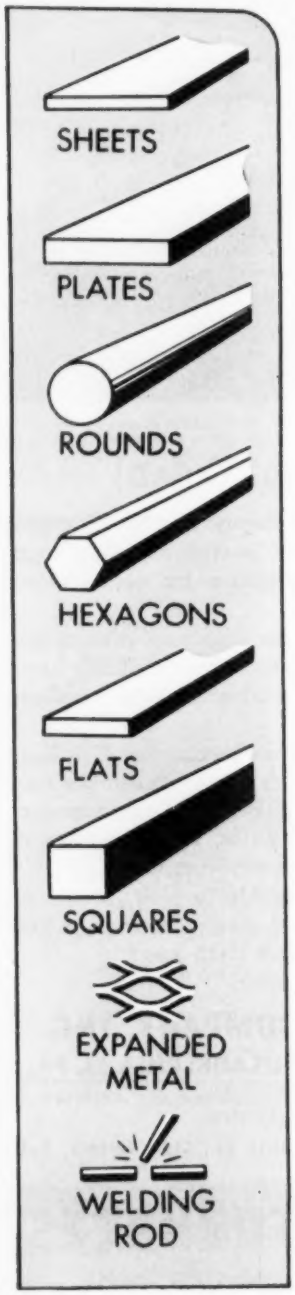
Announcing

ROLLED ALLOYS, INC.

Heat and Corrosion Resistant Alloy Specialists



FORMERLY

ROLLED PRODUCTS DIVISION OF

MICHIGAN STEEL CASTING COMPANY

NOW AN INDEPENDENT COMPANY

HANDLING

ROLLED MILL FORMS OF

CHROME-NICKEL ALLOYS

Besides maintaining our reputation for quality and service, we will have greatly expanded facilities to better serve fabricators and consumers of Rolled Heat and Corrosion Resistant Alloys.

Your past favors have been appreciated and we are looking forward with pleasure to working with you in a prosperous future.

35Ni-15Cr
Type 330

•

25Cr-20Ni
Type 310

•

25Cr-12Ni
Type 309

•

27% Cr
Type 446

•

17% Cr
Type 430

ROLLED ALLOYS, INC.

Heat and Corrosion Resistant Alloy Specialists

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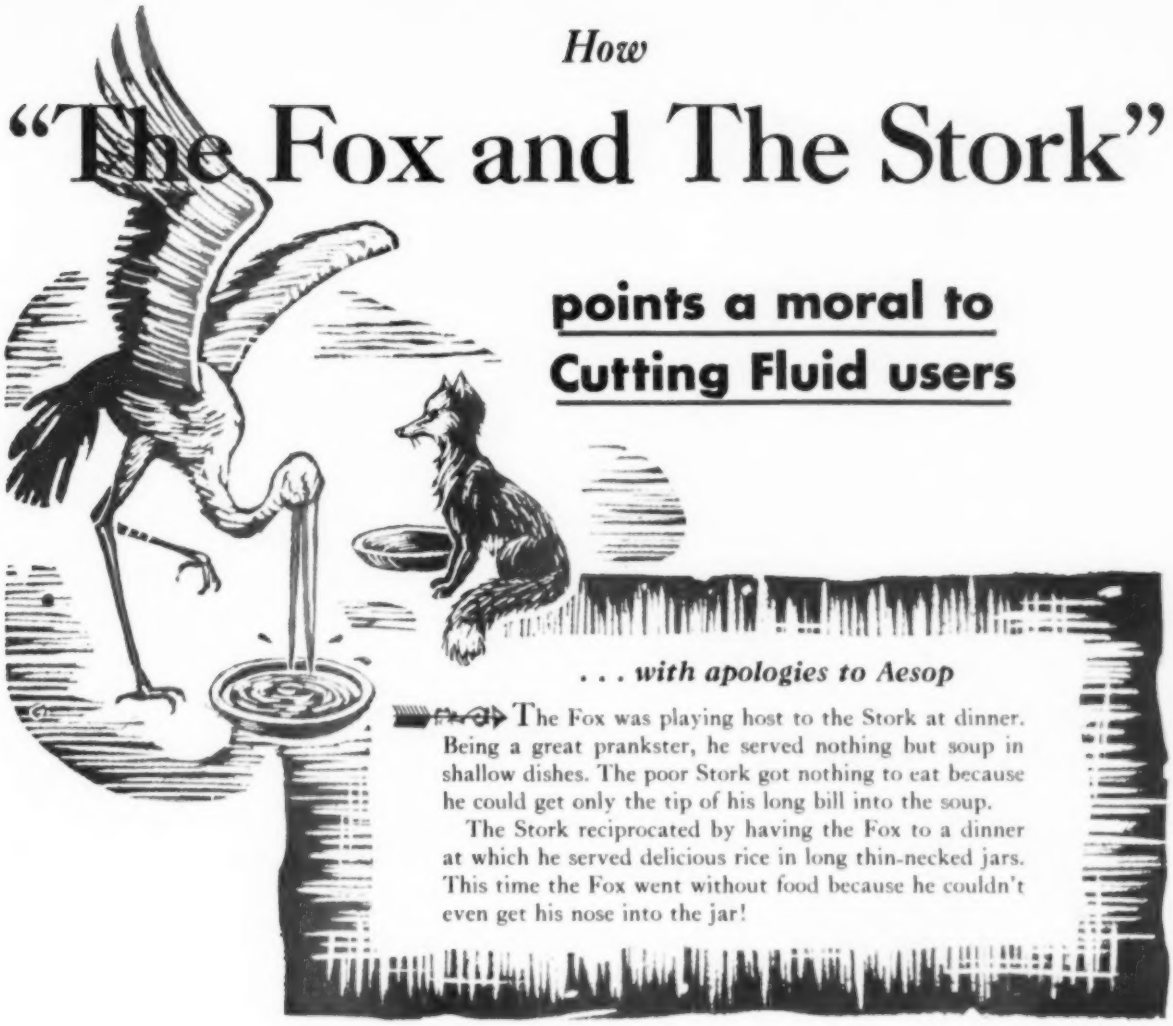
TELEPHONE WALNUT 1-4462

How

"The Fox and The Stork"

points a moral to Cutting Fluid users



. . . with apologies to Aesop

The Fox was playing host to the Stork at dinner. Being a great prankster, he served nothing but soup in shallow dishes. The poor Stork got nothing to eat because he could get only the tip of his long bill into the soup.

The Stork reciprocated by having the Fox to a dinner at which he served delicious rice in long thin-necked jars. This time the Fox went without food because he couldn't even get his nose into the jar!

THE MORAL:

Like the Fox and the Stork in Aesop's fable, each cutting fluid has its own capabilities. When put on an application for which it is not suited the cutting fluid fails to give you the production, tool life or finish possible.

Stuart offers you a vast background of experience in the *selection and application* of cutting fluids, both water-mixed and straight oil types and has the cutting fluids to best meet your requirements. Ask to have a Stuart Representative demonstrate how proper selection and application of cutting fluids saves time, money and materials. Be sure to ask him for the booklet "More Than a Coolant Is Needed."

More Than a "Coolant" is Needed

D. A. Stuart Oil co.
EST 1865 LIMITED

TIME-TESTED CUTTING FLUIDS AND LUBRICANTS

2743 S. Troy St., Chicago 23, Ill.

Free! Dilut-o-graph

Circular slide rule makes dilution of cutting fluids quick, easy! For tanks of 1 to 100 gallons. Fill in coupon, clip to your company letterhead and mail to:

D. A. STUART OIL CO.
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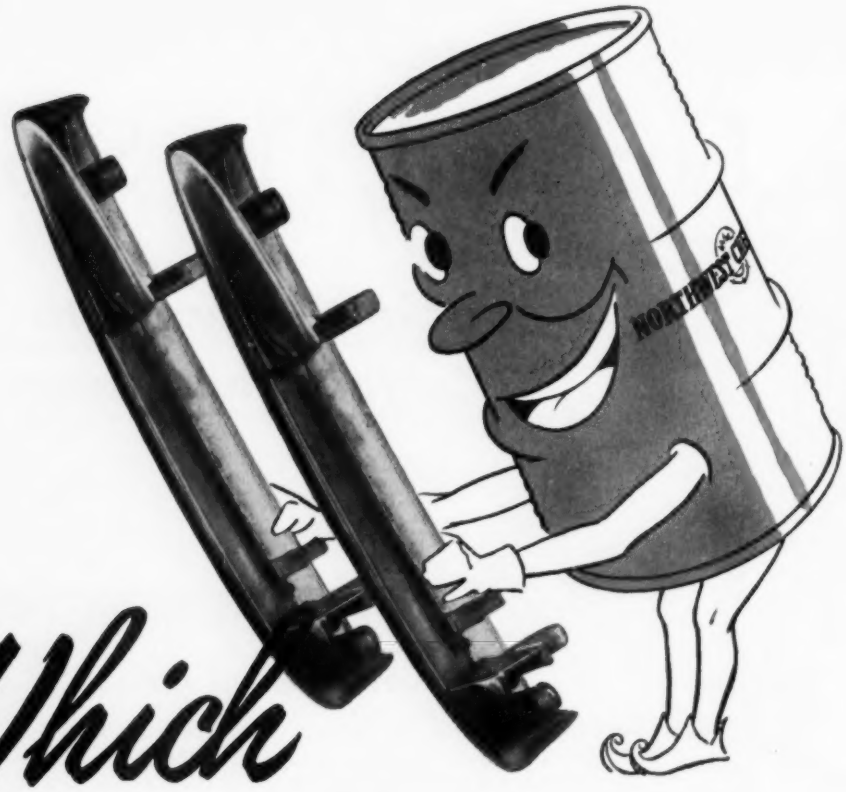
Name .....

Title .....



Which One?

They look alike—they *are* identical—yet one of these parts will wind up as a reject while the other will be the pride of the finishing room.

They both look clean and ready for finish—the difference is that one is "chemically" cleaned with job-adjusted Northwest products while the other got by with a fast dip and rinse.

The finish can be no better than the cleaning job beneath it. Why take a chance with haphazard methods and ordinary chemicals when it costs no more to be *sure* they're clean with a Northwest job-adjusted treatment?

Got a problem? Let our cleaning experts help you!

NORTHWEST CHEMICAL CO.

9310 ROSELAWN DETROIT 4, MICH.

pioneers in pH cleaning control *serving you since '32*

When heat-treating spells "punishment"...

"lowest heat-hour costs"

When cold loading, intermittent operation, high temperature, and fast quenching are the order of the day, furnace parts and fixtures made from Driver-Harris alloys stay on the job—give top-level performance however punishing the heat-treating cycle.

Take a typical example: American Screw Company, of Willimantic, Connecticut says: "We employ a bank of seven American Gas Furnace Company's rotary carburizers, equipped with D-H Nichrome retorts, for case-hardening and heat-treating sheet metal and aircraft screws. Work is loaded cold. Operating temperature is 1650°F. The carburizers are also used occasionally at 1850°F. for hardening of stainless steel. Since we do not "baby" these machines by preheating loads, we consider we have very good success with the Nichrome retorts, each of which delivers, on the average, over 9,000 hours of trouble-free service."

And looking at the record generally, there are innumerable instances to show that Nichrome furnace components are remarkably efficient, economical, and long-lived. Large Nichrome retorts, handling 1800-lbs. of work, have served up to 24,000 hours apiece in rotary gas carburizers at temperatures of 1600°F. to 1650°F.; and Nichrome retorts in vertical carburizing furnaces, operating at 1650°F., have given as much as 36,000 hours of highly satisfactory usage.

It all goes to prove that Nichrome* and other specially developed D-H cast alloys, such as Chromax* and Cimet*, are unexcelled for conventional applications and indispensable for economical operation when heat-treating conditions are unusually tough.

Send us your specifications. Our engineers will be glad to make recommendations based on your particular requirements.

Nichrome, Chromax and Cimet are produced only by

Driver-Harris Company

HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco

*T. M. REG., U. S. PAT. OFF.

MAKERS OF WORLD-FAMOUS NICHROME AND OVER 80 ALLOYS FOR THE ELECTRICAL, ELECTRONIC, AND HEAT-TREATING FIELDS

No. 117 of a Series of Typical Installations

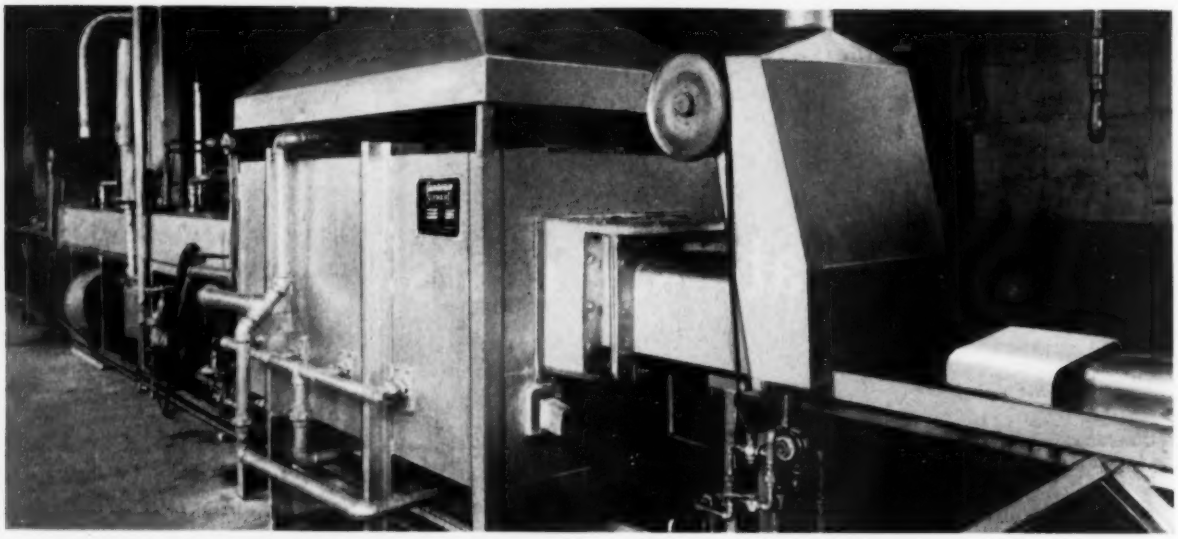
Sunbeam STEWART

THE BEST INDUSTRIAL FURNACES MADE

HOW SUNBEAM INDUSTRIAL FURNACES MEET THE DEMANDS ON THE PRODUCTION FRONT

CLEAN ANNEALING COMPTOMETER CASES AND MISCELLANEOUS SMALL PARTS

AT FELT & TARRANT, Chicago, Illinois



Mechanical calculating machines require precision manufacture and exacting heat treatment because of the wide variety of intricate stampings and cold drawn parts that are employed. Annealing at Felt & Tarrant is done in a Sunbeam Stewart atmosphere-control, gas-fired, pusher-type furnace. *The full muffle atmosphere control has been in continuous use since 1940,* with the exception of the periods of steel shortages, when alternate methods had to be substituted. Operating within the normal annealing and stress relieving temperatures, the original 35% nickel—18% chrome alloy muffle is still in operating condition and is in use at this time. To obtain this exceptional good life, the furnace design required a maximum in heat distribution and combustion characteristics to prevent any possibility of heat concentration and hot spots. This unit is sufficiently flexible to anneal the various size deep drawn steel cases as well as the more intricate smaller parts.

For smaller parts, a secondary fine meshed basket is used to convey the work. Heating chamber dimensions are: 6′ long x 20″ wide x 10″ high.

IF YOU ARE CONSIDERING DEFENSE WORK CALL SUNBEAM. Designs are available for heat treating the following materiel:

SHELLS: 57MM; 75MM; 90MM; 105MM; 120MM; 155MM; 3″, 5″, 6″, 8″ Navy Shells (Harden, Quench and Draw).

FORGINGS: Rotary Hearth and Pusher-type Forging Furnaces.

ARMOR PIERCING SHOT (Harden, Quench and Draw).

CARTRIDGE CASES (Anneal, Stress Relieve).

MACHINE GUN CLIPS (Harden, Quench and Draw).

JET AIRCRAFT and TANK PARTS

Sunbeam STEWART INDUSTRIAL FURNACE DIVISION of Sunbeam CORPORATION

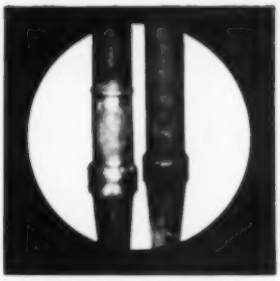
(Formerly CHICAGO FLEXIBLE SHAFT CO.)

Main Office: Dept. 108, 4433 W. Ogden Ave., Chicago 23—*New York Office:* 322 W. 48th St., New York 19—*Detroit Office:* 3049 E. Grand Blvd., Detroit

Canada Factory: 321 Weston Rd., So., Toronto 9

A letter, wire or 'phone call will promptly bring you information and details on SUNBEAM industrial furnaces, either units for which plans are now ready or units especially designed to meet your needs. Or, if you prefer, a SUNBEAM engineer will be glad to call and discuss your heat treating problems with you.

A veteran of 15,000 hours at 1,650°F reconditioned for only $22.50!



ADDING NEW LIFE. When one of the first Inconel radiant tubes ever installed developed a break in the hot leg after four years' use, it was quickly and inexpensively repaired by welding in a new 8-inch section. Note the perfection of the completed weld.

This Inconel® radiant tube is an old timer.

But it isn't on its last legs yet – not by a long sight.

At the ELECTRIC AUTO-LITE plant in Toledo, Ohio, the tube racked up 15,000 hours of exceptionally good service. Exceptionally good, we say, because it operated in a pit-type furnace used to batch anneal small parts at 1,650° F. Few tubes last this long, as you've probably found from your own experience.

After four years, a break finally developed – in the firing leg near the welded joint at the burner casting. The rest of the tube was in excellent shape, so Auto-Lite engineers decided on a salvage job.

Toledo's INDUSTRIAL FABRICATING COMPANY rebored the old burner casting and inserted a new 8-inch section of 3½" OD Inconel tubing with a wall thickness of .109". Using an inert gas shielded arc welding process and "62" Inconel Filler Wire, they joined the new section to the original casting. Then they butt-welded this assembly to the old Inconel tube.

All it cost was $22.50 – and Auto-Lite has a reconditioned Inconel radiant tube that's ready for many more hours of service.

Reports of salvage operations on Inconel wrought furnace and heat-treating equipment are not unusual, for Inconel is one of the most durable high-temperature metals available. Highly resistant to corrosion, embrittlement and destructive oxidation, Inconel serves dependably at temperatures up to 2,200° F. Inconel welds are as heat-resisting and as corrosion-resisting as the alloy itself.

You'll find a great many additional facts about this important alloy in the bulletin, ***Inconel, Workhorse for High Temperatures.*** Your copy is ready and waiting. Write for it now. And consult your distributor of Inco Nickel Alloys for the latest information on availability from warehouse and mill. Remember, too – it always helps to anticipate your requirements somewhat in advance. The International Nickel Company, Inc., 67 Wall St., New York 5, N.Y.

Inco Nickel Alloys

Inconel

...for Long Life at High Temperatures

Here's why it pays to know your HSM

HONEYWELL SUPPLIES MAN

John Kramer, Honeywell Supplies Man in the Cleveland area, shows superintendent Russell Brown of the Belden Brick Company the weather-proof features of the Brown screw type thermocouple head . . . here installed in the crown of a brick kiln.

Ideal for any location, outdoors or indoors where service exposure is severe, this head offers many unusual features. Its unbreakable metal cap fits tightly; prevents moisture and hot, corrosive gases from attacking electrical connections. Threads are *inside* . . . won't rust, corrode or freeze up.

Your local Honeywell Supplies Man will be glad to give full details, and to show you how planned buying . . . the HSM way . . . can bring new economy to *all* your pyrometer supplies purchasing. He's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, 4503 Wayne Ave., Philadelphia 44, Pa.

REFERENCE DATA: Send for Pyrometer Supplies Buyers' Guide No. 100-4.

Below: Brown screw-type thermocouple head on bee-hive kiln at Belden Brick Co.

tool steel is our baby!

Tool steel is our baby. It has been for 52 years. It always will be. That's why tool steel users look with confidence to Crucible.

Crucible's research and development continues to match industry's need for new and improved tool steels. Our metallurgical staff — with a background of thousands of applications is freely available to you. Complete stocks of tool steels are maintained in our conveniently located Crucible Warehouses, for prompt delivery. Turn confidently to Crucible for all your tool steel requirements.

SEND TODAY for the unique Crucible Tool Steel Selector — a twist of the dial gives the tool steel for your application.

Rex® High Speed Steels
Peerless Hot Work Steels
Halcomb 218
Chro-Mow®
Sanderson Carbon Tool Steels
Ketos®
Airkool Die Steel
Airdi® 150
Nu-Die V Die Casting Steel
CSM 2 Mold Steel
La Belle® Silicon #2
Atha Pneu

SPECIFY YOUR TOOL STEELS BY THESE BRAND NAMES

Crucible Steel Company of America
Dept. MP, Chrysler Building, New York 17, N. Y.

Name_____

Company_____ Title_____

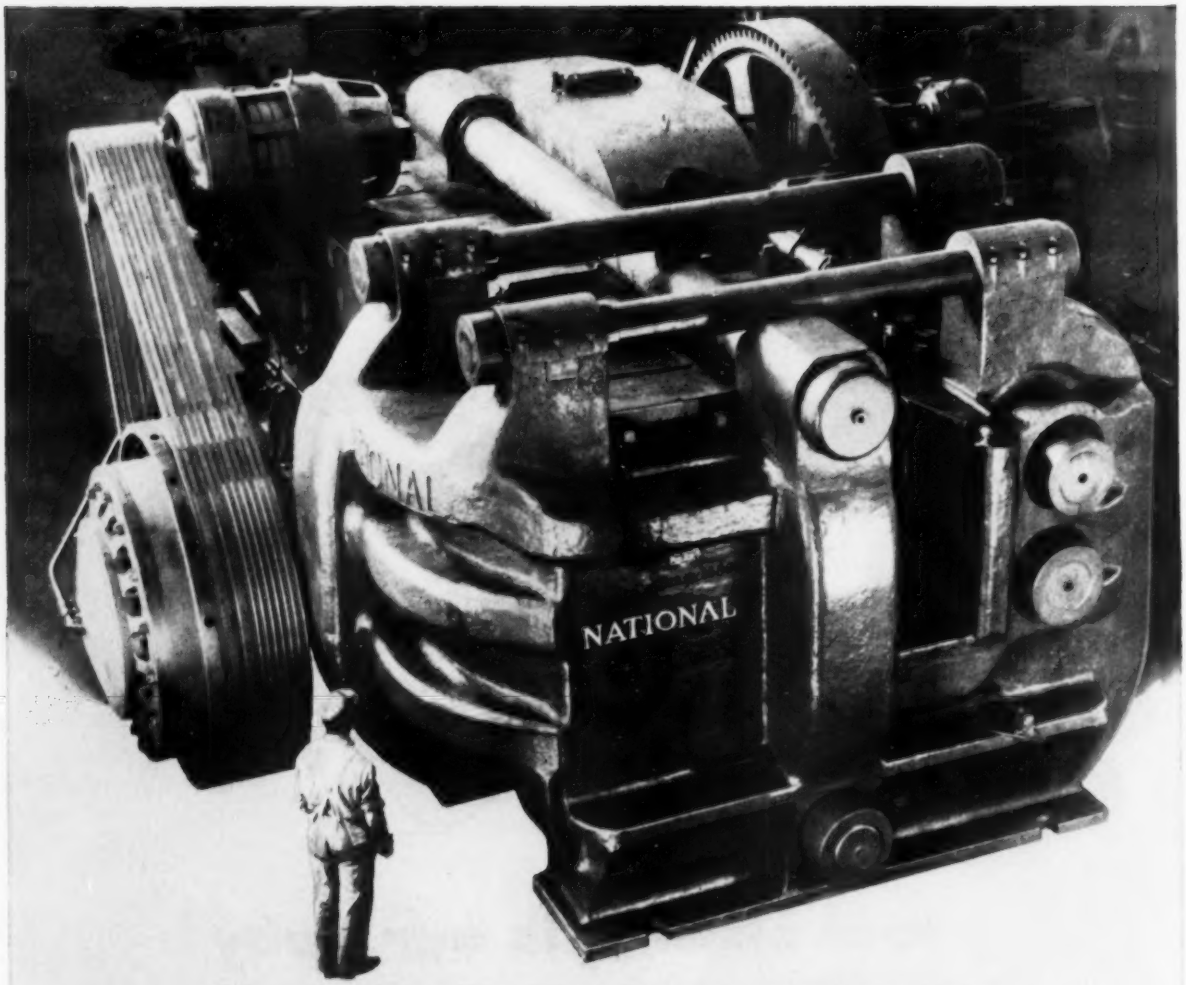
Address_____ City_____ State_____

9" diameter, 3-colors

CRUCIBLE first name in special purpose steels

52 years of Fine steelmaking

TOOL STEELS



FOR DEEP-PIERCING AND UPSETTING!

Built into National Forging Machines is the ability to take in stride difficult deep-pierce and upset-forging jobs.

Rigid, long-running National upsetters, coupled with National's long-established die engineering experience, result in (1) A superior more-accurate forging; and (2) Increased round-the-clock lower-cost production.

THIS DOOR IS ALWAYS OPEN

Forgemen *still* choose National Forging Machines for their difficult work, and *still* come through our Open Door for assistance with their forging problems.

NATIONAL
MACHINERY COMPANY
TIFFIN, OHIO—SINCE 1874

DESIGNERS AND BUILDERS OF MODERN FORGING MACHINES • MAXIPRESSES • REDUCEROLLS • COLD HEADERS • BOLTMAKERS • NUT FORMERS • TAPPERS • NAILMAKERS

Hartford Detroit Chicago

U. S. DRILL HEAD COMPANY SAYS . . .

HEAT TREATING ELIMINATED

- REJECTIONS REDUCED
- WEARABILITY INCREASED AND

COSTS CUT 50%

WITH

STRESSPROOF®

SEVERELY COLD-WORKED, FURNACE-TREATED STEEL BARS

Multiple spindle, made by U.S. Drill Head Company, Cincinnati, Ohio, uses spindles made from STRESSPROOF.

• Spindles for these multiple drill-heads must be straight. Formerly heat-treated, straightening was a difficult, costly job, and rejections were high.

Now produced from STRESSPROOF, heat-treating, with its attendant straightening problem, is eliminated; machinability is increased 25%; wearing properties have been improved; and costs reduced 50%.

STRESSPROOF makes a better part at a lower cost.

STRESSPROOF's value to manufacturers like U.S. Drill Head stems from its unique combination of four qualities in the bar: (1) Strength, (2) Wearability, (3) Machinability, and (4) Minimum Warpage. Yet STRESSPROOF costs less than other quality cold-finished steel bars. It comes in cold-drawn or ground and polished finish.

SEND FOR . . .
Free Engineering Bulletin
"New Economies in the Use of Steel Bars"

La Salle STEEL CO.

Manufacturers of the Most Complete Line of Carbon and Alloy Cold-Finished and Ground and Polished Steel Bars in America.

La Salle Steel Co.
1424 150th Street
Hammond, Indiana

Please send me your STRESSPROOF Bulletin.

Name_____

Title_____

Company_____

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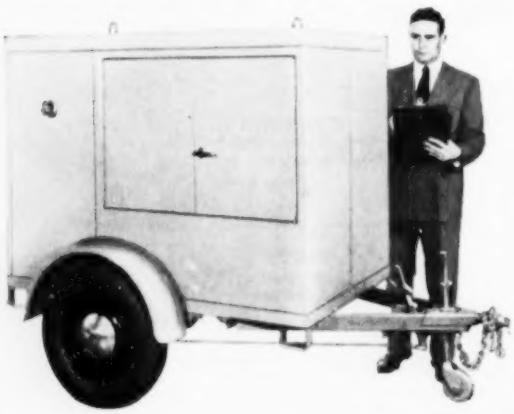
NOW — a *truly* portable industrial x-ray unit!
The General Electric RESOTRON 250

Compact, lightweight, 250,000-volt x-ray unit speeds inspection of large structures, saves many hours of set-up time



For radiographic examination of welds or castings in large structures, the new GE Resotron 250 offers unprecedented advantages. Completely housed in a cabinet only 4 x 6 x 4-foot high, which may be trailer-mounted, this unit can be set up anywhere in a few minutes by one or two men.

Small, lightweight tube head can be passed through a 15-inch diameter opening for interior inspection of large vessels. It's particularly adapted for ship hulls, pressure vessels, steam pipes. No cranes or elaborate rigging needed — can be manipulated manually.

Resotron 250 is the latest addition to the complete GE line of industrial x-ray apparatus . . . ranging up to 2,000,000-volt units and betatrons. It is actually a miniature of the famous General Electric million-volt Resotrons, with such time-proven features as resonant transformer, cascade tube and gas insulation.

Have you inspection problems the Resotron 250 might solve? See your local GE x-ray representative. Or write X-Ray Department, General Electric Company, Milwaukee 1, Wis., Rm. AS-2.

GENERAL ELECTRIC

Superior

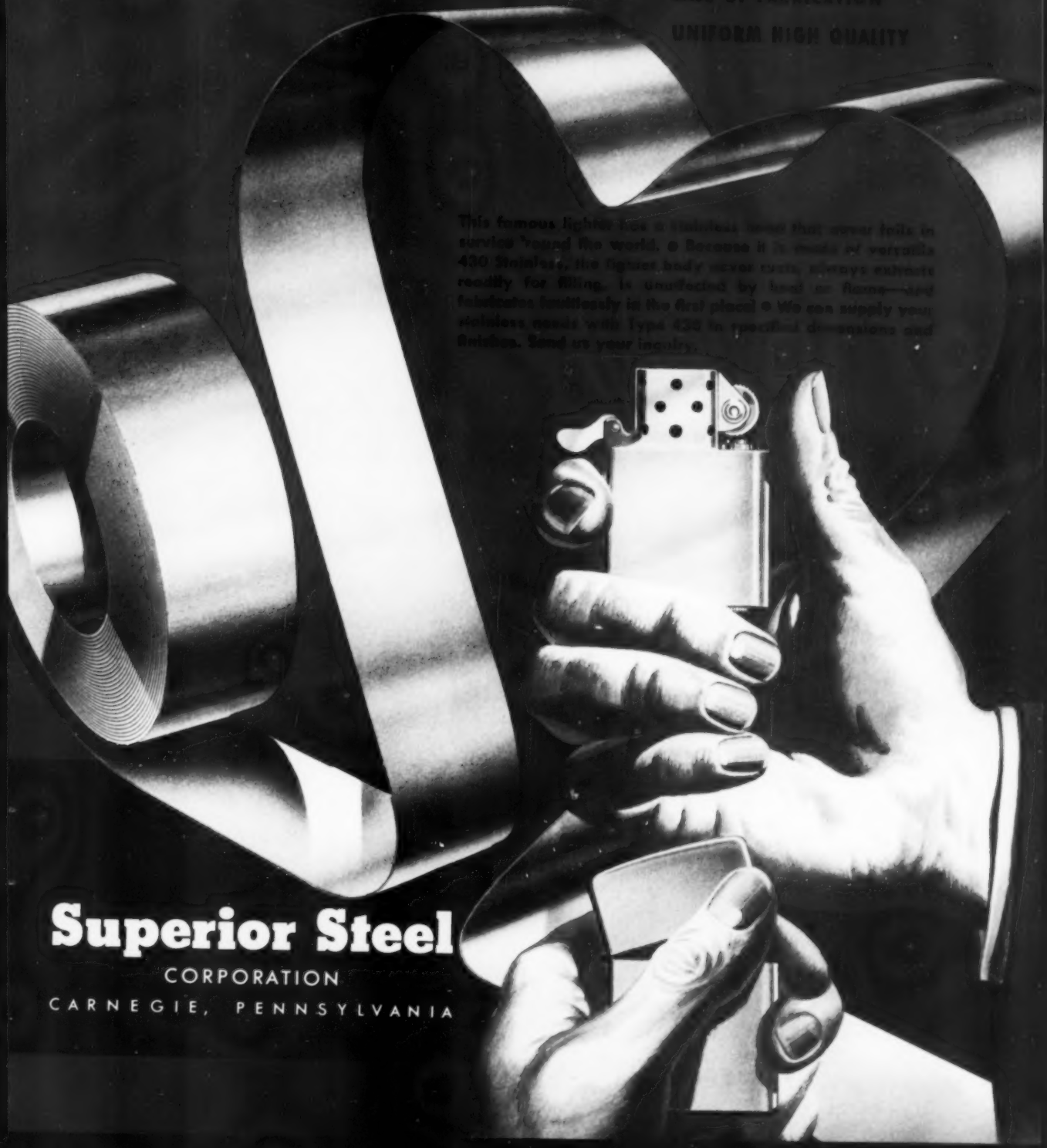
TYPE 430

STAINLESS STEEL

The Heart of the Lighter

FOR HEAT RESISTANCE
RESISTANCE TO CORROSION
EASE OF FABRICATION
UNIFORM HIGH QUALITY

This famous lighter has a stainless heart that never fails in service 'round the world. ● Because it is made of versatile 430 Stainless, the lighter body never rusts, always extracts readily for filling, is unaffected by heat or flame—and fabricates faultlessly in the first place! ● We can supply your stainless needs with Type 430 in practical dimensions and finishes. Send us your inquiry.



Superior Steel
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CARNEGIE, PENNSYLVANIA

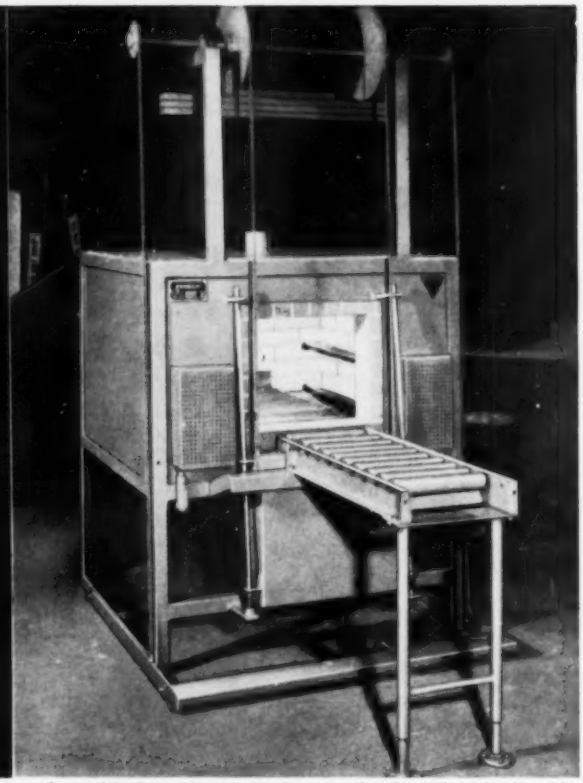
Wanted!

High Temperature problems for

GLOBAR

TRADE MARK

Heating Elements



Furnace manufactured by Pereny Equipment Co., 843 Chambers Rd., Columbus, Ohio

What are *your* problems in the medium and high temperature electric furnace field? We're looking for tough ones requiring temperatures up to 2750°F. We work with furnace manufacturers and furnace users to solve many problems with dependable GLOBAR Brand silicon carbide heating elements by CARBORUNDUM.

Pereny, for example, chose GLOBAR Heating Elements for the new Model RH-68 Pereco Electric Roller Hearth Furnace, shown here. Designed and built for faster, easier handling of heavy loads—such as large tools or dies—heat treated at temperatures ranging from 1400° to 1500°F. The chamber, 15″ wide x 30″ deep x 15″ high, is heated by four GLOBAR Heating Elements.

GLOBAR Heating Elements provide heat that is uniform, easily controlled, fast, safe, clean and quiet. They give long, trouble-free service. Replacement, when necessary, is accomplished quickly—with no long production delays.

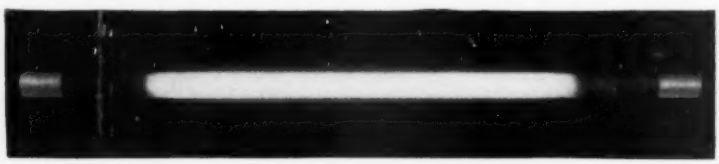
If you have any problems in the medium and high temperature field, our engineering service is offered without obligation on your part. Address Dept. MP 87-32.

GLOBAR

TRADE MARK

Heating Elements

by CARBORUNDUM



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87-32

an **ACCO** product

Sphero-Conical DIAMOND **BRALE*** PENETRATOR for Hardened Steel

HOW IT WORKS

A. Minor Load Penetration

B. Major Load Penetration

C. Linear measurement of penetration increase which "ROCKWELL*" converts to hardness reading

BRALE Penetrator Accuracy Is Proved in Wilson's Standardizing Laboratory

● One point of hardness on the Rockwell C scale equals .00008" so penetrator accuracy must be constant. That's why Wilson maintains its Standardizing Laboratory for testing on many test blocks and approving every BRALE penetrator.

Each BRALE is precision ground to shape under high magnification and is accurate to the degree required for a research laboratory. Wilson's BRALE Penetrator gives true readings at all points on the dial. To get the greatest accuracy from your hardness tester, see that it is equipped with a diamond BRALE penetrator.

*Trade Mark Registered

WILSON "ROCKWELL" and TUKON Hardness Testers

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Write for literature

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AMERICAN CHAIN & CABLE

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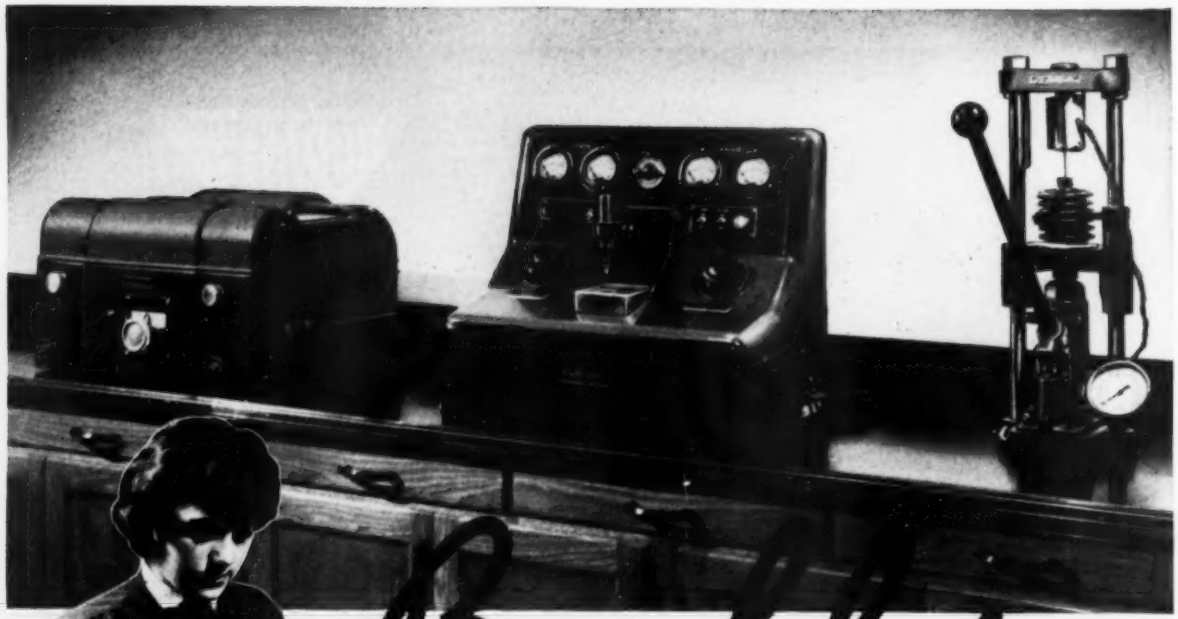

Buehler...

METALLURGICAL LABORATORY EQUIPMENT

Operator using the new Model No. 1506 low speed polisher. Section of laboratory equipped with No. 1251 Duo Belt Sander—No. 1700 Electro Polisher—No. 1315 Press.

. . . provides the metallurgist with the most complete line of modern designed precision machines for specimen mounting and preparation available anywhere in the world. This finely made equipment has been developed through a thorough understanding of the requirements of the metallurgist and a rigid insistance on perfection in the mechanical design and construction of each item.

Everything needed for metallurgical testing from cut-off machines, moulding presses, and grinders to the mechanical or electrolytic polishers is included in the Buehler line.

In setting up complete laboratories or adding items to present equipment the metallurgists will find in the Buehler line of coordinated equipment everything needed for producing the best work, with speed and accuracy.

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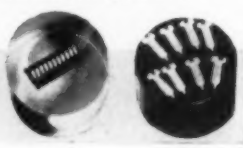

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. . . and held for further questioning. Every Sivyer casting is considered guilty of flaws until proven innocent. That's why rigid inspection follows each casting through manufacture . . . to insure compositional accuracy . . . internal integrity . . . narrow dimensional tolerances. Every casting carrying the Sivyer Ⓢ has been through the third degree of painstaking inspection to assure a better casting value for you.

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The sign of a casting with a "clean record." Get acquainted with the famous Sivyer Ⓢ — the sign of better steel castings. Inquiries promptly handled.

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An example is illustrated above. The customer, Fenwal, Incorporated of Ashland, Massachusetts, manufactures THERMOSWITCH® industrial thermostats; Aircraft temperature controls, fire and overheat detectors; DETECT-A-FIRE® fire detectors. All of these products use stainless steel tubing. Before consulting with us an extra machining operation on the inside diameter was required. The tubing used needed a special temper for softness.

Problems like this one are tailor made for Superior. We produced for Fenwal a tube with a smooth, clean, almost mirror-like inside finish to eliminate the need for the extra machining operation. We were able to do this while still maintaining the low physicals necessitated by a stress cracking possibility.

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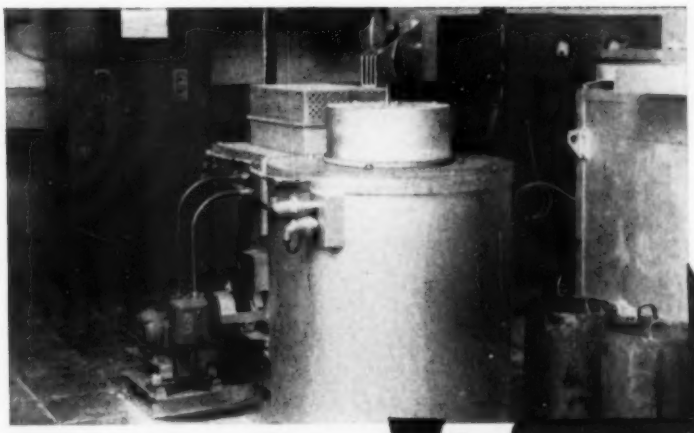

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La Compagnie Singer in Paris is but one of the many manufacturers throughout the world who use Lindberg heat treating furnaces. At the Singer plant, high speed tools are hardened in Lindberg "Hydryzing" furnaces*. And tempering is handled in Lindberg "Cyclone" tempering furnaces*.. utilizing the famous forced convection heating principle. For details and "case history" information contact your nearest Lindberg representative.

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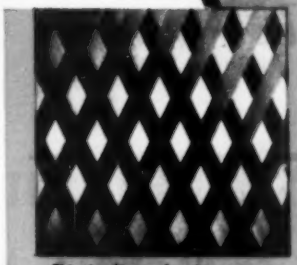
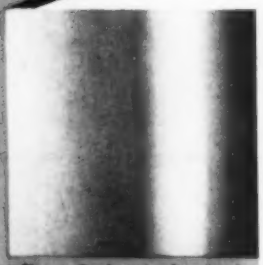
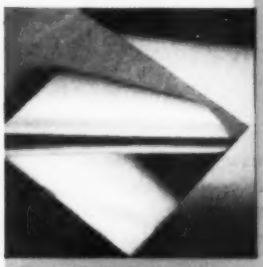


This is diamond stripe pattern, available in any desired base metal.

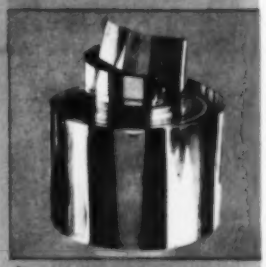


Chrome Steel, satin. Pre-plated. Chrome available in sheets, coils.

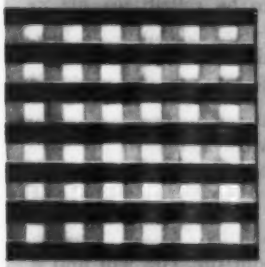


This is Mar-Not, paper adhered, to ease fabrication and handling.

This is Copper plated steel. Lacquer coat recommended.

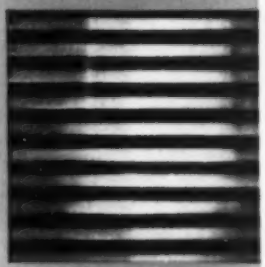


Steel base metals available in coils up to 24" wide.



This is square crimp Chrome Zinc. Other crimps also offered.

Pre-plated metal, Chrome bright. May be plated one or two sides.



Horizontal stripe pattern; a striking, modern pre-plated design.

For broiling — a compact, beautiful electric infra-red combination Rotisserie and Broiler. Uses Nickeloid pre-plated Chrome Steel.

For door chimes — ivory plastic cover with satin brass or chrome tubes of pre-plated steel.

In the design and construction of your product, there may be practical possibilities for the adaptation of Nickeloid pre-plated metals. The basic soundness of pre-plating (finishing before fabrication) was never more apparent than today. This 55-year-old idea is being successfully proved on thousands of applications to be seen on the counters and shelves of the American marketplace.

BUILD *QUALITY* INTO YOUR PRODUCT

Kitchen canister set. A popular housewares item, made of Chrome Steel, bright finish.

AMERICAN NICKELOID COMPANY

Established 1898

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You should know the facts about

TIN

Tin is one of the most economical production metals known to industry. Used in combination with other metals, as it always is, a little tin does a lot of work.

The tin can proves this point, for the amount of tin in some cans is a coating less than 1/10,000 of an inch thick. But what a vital coating this is to the health of the nation. It makes the tin plate rust resistant and nontoxic, preserving the food in the can.

In every state of the United States—Nevada alone excepted—tin is utilized for processing and preserving the nation's food supply. It keeps fresh, unspoiled and tasty the contents of over 22 billion tin cans a year.

TIN
is vital to the free world

Tin is indispensable to this nation's health, industrial progress, transportation, communications, standard of living, and security.

Yet we continue to strive for substitutes for tin . . . for that elusive something "just as good." Why? Does it make sense, in our headlong rush through this atomic age, to try to replace one of the most valuable materials of all?

Can something "just as good" be found that is nontoxic and malleable; that can be rolled, pressed or hammered; that can prevent rust and protect other metals; that is so essential to the usefulness of antifriction metals, bell metal, gun metal, pewter and solder?

Why look? Why bother? Whatever the demand for tin may be for industrial uses, Malaya, one of the Free World's staunchest allies, can continue to supply it on a free market.

"Tin News" is a monthly newsletter packed with current facts and information about tin. You will find it interesting, informative, stimulating and useful. A copy is yours regularly, and with our compliments, if you would like to have it.

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One foundry, melting stainless steel, recovers 99% of the chromium charged...saves $60,000 a year in reduced losses of this single element.

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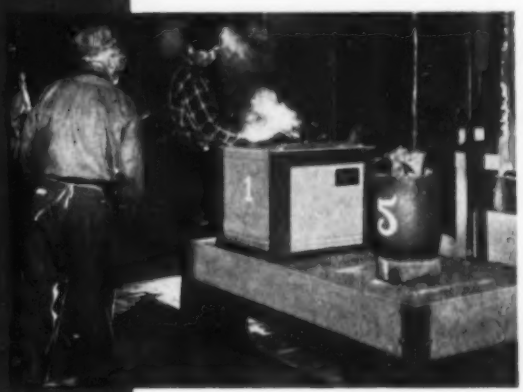

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150

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We can learn from bankrupt Micawber

"MY advice, Copperfield, you know. Annual income twenty pounds, annual expenditure nineteen-nineteen-six, result happiness. Annual income twenty pounds, annual expenditure twenty-ought-six, result misery. The blossom is blighted, the leaf is withered—in short you are forever floored. As I am!"

This is probably the most famous financial counsel in all English literature, offered a hundred years ago by Charles Dickens' character the bankrupt Micawber to the hero David Copperfield. As advice it is just as good in 1953 as it was in 1849, and just as sound for a nation as for an individual.

In 17 of the last 20 years, Uncle Sam has followed Micawber's practice, not his advice. Our national balance sheet has been, figuratively, "annual income twenty pounds, annual expenditure twenty-ought-six". Ahead of us as a nation, if we continue this irresponsible policy, is Micawber's dire predicament, "blossom blighted, leaf withered—forever floored".

There is no sane reason why the world's richest nation should continue to live the financial life of a profligate bankrupt. It is time now to set our house in order. The program called for is simple: (1) Eliminate waste and extravagance in government spending; (2) Balance the Federal budget; (3) Control the national debt and reduce taxes.

By such positive action we can protect future happiness—and prevent misery—for ourselves, our children and our children's children.

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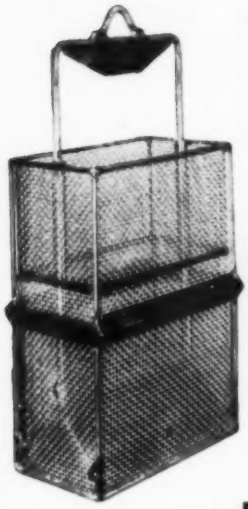
ROLOCK

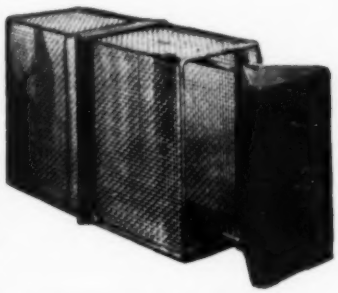
FABRICATED ALLOYS

HEAT AND CORROSION RESISTANT



Drop-bottom salt pot basket (left) has lifting bars attached to solid sheet bottom. When assembly sets into holder frame over quench tank, bottom drops, releases load.

At right is a heavy duty basket with extra rugged hinged bottom, released instantly by disengaging lever from pin. Note single point suspension.



DROP-BOTTOM BASKETS for fast release of load

Both baskets were fabricated-welded from alloys best suited for the exposures, and like other Rolock products, were job-engineered to suit the specific use. Among the thousands of designs created by Rolock engineers there are many that, with slight changes in shape or size, will fill the requirements of your heat treating plant or department.

To help you solve such problems we offer two excellent catalogs... No. B-8 Heat Treating Section and No. B-9 Corrosion Resistant Section. They picture and describe a great variety of designs in Baskets, Crates, Trays, Racks, Fixtures, Screens, Grids, Retorts, Muffles, Tanks, Sinks, Hooks, Chains, etc.

Especially of interest to producers of ordnance is the new Rolock equipment for processing Steel Shell Cases... handling several sizes of cases thru fourth draw in a cycle of processes. This is an example of unequalled versatility under difficult conditions.

We have put more practical material into Catalogs B-8 and B-9 than you will find in any other similar publications. COPIES ARE AVAILABLE ON REQUEST.

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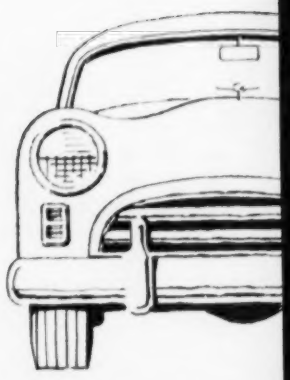
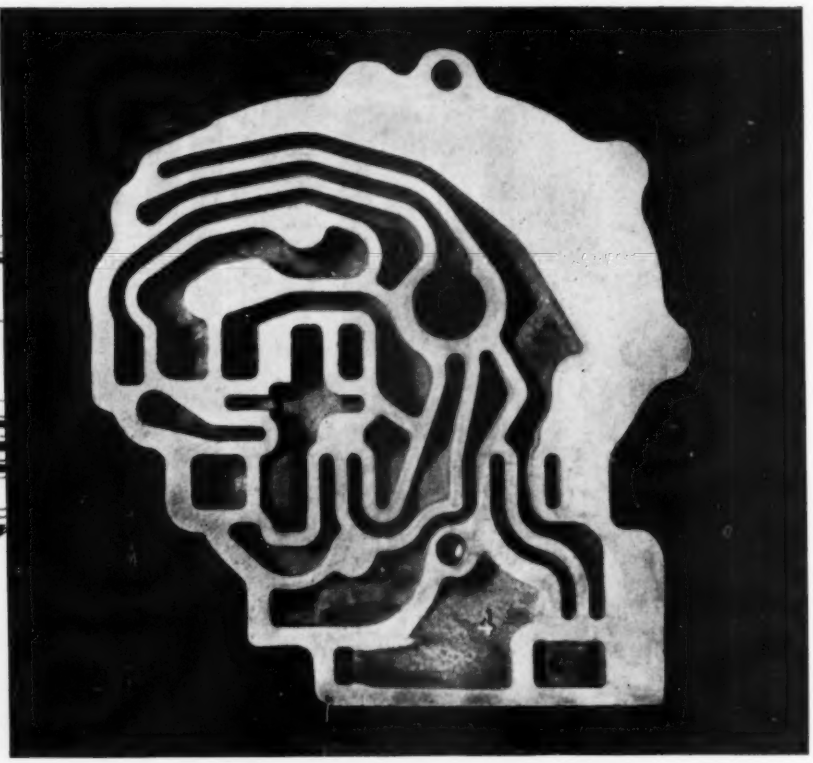


This intricate maze of metal is the valve section of a popular automatic transmission, cast in Gray Iron.



6 Reasons why the final choice was GRAY IRON!

1. Greater rigidity, strength and dimensional stability
2. Greater accuracy—can be held to closer tolerances
3. Greater wear resistance
4. Does not permit dirt to imbed, as do the softer nonferrous materials
5. Desirable thermal expansion characteristics
6. Economy

Intricate components such as the section shown here are economically practical only as integral castings. The final question then becomes—in what material shall they be cast?

This valve section was first experimentally cast in a nonferrous material. However, the final choice was Gray Iron, for the practical reasons listed at the left. These same basic advantages of Gray Iron could well apply to one of *your* current design problems.

Write for technical information on the many advantages of the Gray Iron casting process.

Make it Better with Gray Iron
Second largest industry in the metal-working field

GRAY IRON FOUNDERS' SOCIETY, INC.
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"We solve depth-of-hardness problems on low hardenability steels with GULF SUPER-QUENCH"

says James Mericka, President
Steel Improvement Co., Detroit, Mich.

"One of our current jobs is quenching and drawing 1¼ x 22 in. cold-rolled pins for tank tractor treads," says Mr. Mericka, "and we have to through-harden these pins to 35-40 Rockwell C. Ordinarily this is quite a problem with some of the substitute steels, such as AISI 8150 and 8160."

"But by using Gulf Super-Quench, we've been able to meet this hardness specification on every substitute steel delivered to us. And we get a minimum of distortion and cracking with this fast-quenching oil, which results in fewer rejects and an improved profit picture."

This is typical of the results obtained in scores of metal-working plants with Gulf Super-Quench. For additional information on this quality fast-quenching oil, call in a Gulf Sales Engineer. Write, wire, or phone your nearest Gulf office.

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GULF REFINING COMPANY
PITTSBURGH 30, PENNSYLVANIA

GULF SERVES INDUSTRY

Furnace linings last longer

when they are made of Norton-engineered Special Refractories

Fewer shut-downs and more continuous operation is always the story when linings are made of Special Refractories engineered to your job by Norton. Whether you are melting ferrous or nonferrous metals there are Norton mixtures for a wide variety of successful applications that mean more metal melted per lining, fewer furnace shut-downs and generally lower costs.

There are so many complications in metal melting, involving chemical, electrical and physical conditions it will pay you to take advantage of Norton's 40 years' experience in solving Special Refractory problems like yours.

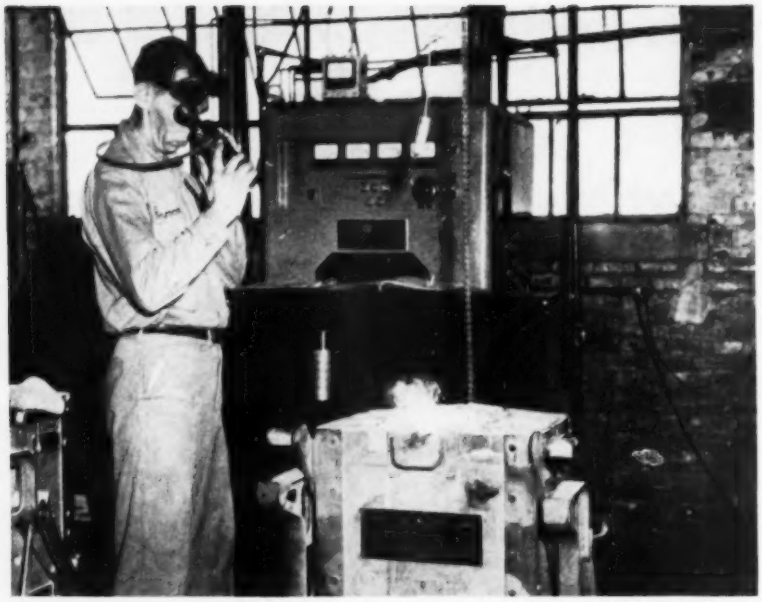
Many different materials

Norton furnishes Special Refractory grain, cements and bonded shapes in a wide variety of mixtures each engineered for a particular set of conditions.

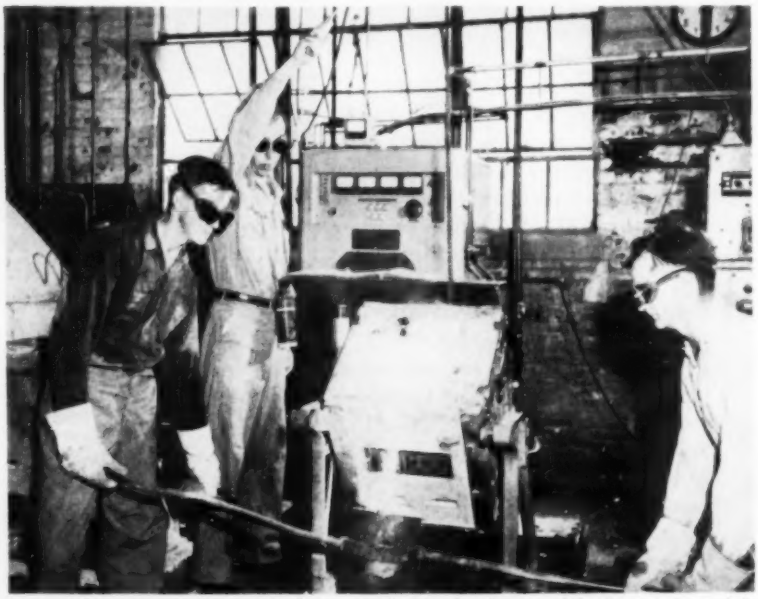
Such special Refractory Materials as CRYSTOLON* (silicon carbide), ALUNDUM*, FUSED STABILIZED ZIRCONIA.

What is your problem?

We believe you will benefit by consulting your nearby NORTON Representative or writing Norton Company, 321 New Bond Street, Worcester 6, Mass. *Canadian Representative:* A. P. Green Fire Brick Co., Ltd., Toronto, Ontario.



Taking the Temperature reading on the melt at the Metalmold Corporation plant at Groton, Mass. Temperatures go 3200° F. and higher. MAGNORITE* grain placed between the crucible and the coil has such high rammed density that it offers great resistance to penetration, erosion and chemical attack.



Longer Life for Furnace Linings can be expected when the right special refractory is used. In this plant they count on MAGNORITE to prevent short circuits in the event of crucible breakage. MAGNORITE keeps metal from reaching the primary coil of the furnace.

*Trade-Marks Reg. U. S. Pat. Off. and Foreign Countries

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TOOL STEEL FROM RYERSON

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Steel procurement is trouble enough these days without adding unnecessary steps. That's one reason why many shops are ordering tool steel from Ryerson, their regular warehouse steel source. And with every shipment of Ryerson tool steel you get exact instructions on how to harden. Water, oil and air hardening types in stock—also ground flat stock.

Today, when Government restrictions are enforcing the use of leaner alloys with unfamiliar heat treatment response, you'll find Ryerson Alloy Service more helpful than ever. The tests we make to assure quality, verify analysis and guide your heat treating are your best protection against production difficulties, costly breakdowns.

For example, we spark test our alloy stocks to guard against mixed steels. And we put every heat of Ryerson as rolled and annealed alloy through four separate hardenability tests. The result: positive hardenability knowledge of the particular steel shipped to you.

All test information—hardenability, analysis, etc.—is carefully recorded on a Ryerson Alloy Certificate delivered with your steel as a guide to heat treatment. So don't take today's alloys for granted. Order from Ryerson by hardenability as well as analysis—and be doubly sure.

Stocks include low, medium, and high carbon alloys in all finishes and conditions.

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Four-Piece Composite Trimmer Die Sketched in Fig. 2

Short Cycle for Hardening High-C, High-Cr Toolsteel

by J. Y. RIEDEL

Toolsteel Engineer, Bethlehem Steel Co.

HIGH-CARBON high-chromium toolsteel of the 1.50% carbon, 12% chromium type (S.A.E. designation D2) is a widely used type of steel wherever maximum production is required in cold working operations. Typical applications are blanking, forming, punching, and drawing.

The heat treatment required for hardening this steel is more complex than that required for hardening the common water hardening or oil hardening toolsteels. Due to the high alloy content of this steel, it is not properly hardened by heating a little above the Ac_3 critical point and quenching, since the carbides present dissolve at an extremely slow rate. Therefore it is ordinarily hardened by heating to a temperature 200 to 250° F. above the Ac_3 critical and holding at this temperature long enough for proper carbide solution. Full hardening can then be effected by cooling the tool in air.

Because of this high quenching temperature (usually 1850° F.) ordinarily used on high-carbon high-chromium toolsteel, excessive decarburization would occur with conventional fuel-fired furnaces. Pack hardening is therefore universal in shops not equipped with controlled atmosphere furnaces or salt baths.

Pack hardening from relatively high temperatures has resulted in heat treatment cycles of considerable length; 24-hr. cycles or longer are not uncommon. The long cycles required to harden this grade properly have always been a source of irritation, but attempts at short cuts often produced improperly treated tools.

High-carbon high-chromium steel is similar to high speed steel in that its carbides dissolve very slowly at temperatures just above the Ac_3 critical point. The high quenching temperatures conventionally used on high speed steel were discovered in a systematic investigation using quenching temperatures far higher than would be considered safe, yet the prime purpose was to accelerate carbide solution. In our study of the high-carbon high-chromium toolsteel we thought it should be capable of reacting to high temperature quenching in the same manner as high speed steel. If this were found to be true, the time required to harden tools made therefrom could be decreased to a small fraction of the time usually required. This paper deals with the investigation of this possibility.

One-inch round bar stock of the following composition was used in this work: C, 1.54%; Mn, 0.38; P, 0.018; S, 0.010; Si, 0.48; Ni, 0.17; Cr, 11.50; V, 0.30; and Mo 0.80%.

To determine the length of time required for the center of 1-in. round specimens to be raised from a preheat temperature of 1500° F. to a high heat temperature, several specimens 5 in. long were cut from the stock, a ⅛-in. hole drilled 2½ in. deep into one end and a thermocouple cemented in the hole. Test runs were made by preheating at 1500° F. for 45 min., transferring the specimen to a high heat furnace at various temperatures (1850 to 2350° F.) and recording the time required for the center

thermocouple to indicate furnace temperature. The average time to reach all temperatures tested was approximately equal (5¼ min.) and this was used as the holding time at high heat for all quenching temperatures investigated.

Effect of Quenching Temperature – Eleven 5-in. specimens were preheated 45 min. at 1500° F. and then transferred into a high heat furnace at temperatures ranging from 1850 to 2350° F., held 5¼ min. and air cooled (quenched) to room temperature. After measuring the Rockwell hardness, the specimens were chilled in liquid nitrogen at −319° F. for one hour and retested for hardness. Results of the hardness tests are shown in Table I. By way of comparison, similar specimens treated in the conventional manner (pack harden from 1850° F., 3 hr. at heat) show Rockwell C-65 as-quenched, and C-66 after subzero chill.

The results of this series of tests are interpreted as follows, with regard to the effect of holding time at the quenching temperature:

I. At temperatures from 1850 to 1950° F., full hardness cannot be attained because of insufficient carbide solution.

II. At temperatures from 2000 to 2100° F., sufficient carbide solution has occurred for full hardening to result. Quenching from this temperature range produces low as-quenched hardness because of retained austenite. The development of full hardness by subzero chilling shows that the retained austenite can be transformed readily.

III. At temperatures from 2150 to 2350° F., sufficient carbide solution has occurred so as to produce large amounts of retained austenite which are so stable that they do not fully transform during subzero chilling.

At this point in the investigation it was apparent that 1-in. specimens of high-carbon high-chromium toolsteel could be hardened in relatively short time by the following cycle:

1. Preheat – 1500° F. (45 min. at heat).
2. High heat – 2000 to 2100° F. (5¼ min. in furnace).
3. Air cool to room temperature.
4. Subzero chill in liquid nitrogen (1 hr.).
5. Temper to desired hardness (usually Rockwell C-60).

Some further work was done to devise means whereby subzero chilling could be avoided because most shops do not have liquid nitrogen available and because subzero chilling is prone to crack the tools. Preliminary work with tempering temperatures in the range of 1000 to 1050° F. had shown that the retained austenite in specimens quenched from 2100 and 2150° F. could be most readily transformed to produce full hardness. A tempering series was therefore conducted on two groups of specimens, one of which was quenched as in Steps No. 1 and 2 (above) from 2100° F.; the second group was quenched in a similar manner from 2150° F. These specimens were immediately tempered for 2 hr., and after air cooling to room temperature were retempered for 2 hr. at the same temperature. Table II shows hardness produced by various tempering temperatures.

The tempering series shows that the austenite retained by high-temperature quenching (by air cooling from the hardening heat) can be transformed by the proper selection of tempering temperature. After a 2100° F. quench, tempering in the range 950 to 1000° F. produces the range of hardness (approximately Rockwell C-60) usually desired in tools made of this steel. When a 2150° F. quench is used, only a slight amount of transformation occurs in a 1000° F. temper; a temperature of 1050° F. is needed to cause

Table I – Hardness Vs. Quenching Temperature

Quenching Temperature	Rockwell Hardness	
	As Quenched	After Chilling
1850° F.	C-60	C-60
1900	60	62
1950	61	64
2000	61	65
2050	60	66
2100	58	65
2150	46	63
2200	43	57
2250	39	44
2300	37	40
2350	37	38

Table II – Hardness Vs. Tempering Temperature

Tempering Temperature	2100° F. Quench (C-58)		2150° F. Quench (C-46)	
	1st Temper	2nd Temper	1st Temper	2nd Temper
850° F.	C-55	C-55	C-44	C-45
900	56	57	45	46
950	60	61	46	47
1000	61	61	47	49
1050	58	55	57	59
1060	–	–	60	–
1100	53	50	54	50
1150	48	46	47	45

appreciable transformation of the retained austenite. Actually, 50° F. increments of tempering temperature are not small enough to indicate how to develop the peak hardness after a 2150° F. quench; a 1060° temper will produce a hardness of Rockwell C-60 after a 2150° quench.

Quenched specimens from the series in Table I were examined microscopically to determine whether eutectic melting had occurred at any temperature. The specimens treated at 2300 and 2350° F. showed definite eutectic, indicating overheated metal; tools treated from 2300° F. or higher would be useless because of resulting brittleness. This indicates that quenching temperatures *up to* 2250° F. could be safely used if properly transformed to the desired hardness. The exact tempering temperatures required to transform austenite retained in 2200 and 2250° F. quenches have not been exactly determined, but are in the range of 1075 to 1100° F.

Recommended Treatment – A conservative short cycle for hardening 1-in. diameter specimens of high-carbon high-chromium toolsteel without the necessity of subzero chilling can now be outlined as follows. (Sections larger than 1 in. can be treated in a similar manner by increasing the heating time in proportion to the size of the tools.)

1. Preheat – 1500° F. (45 min. at heat).
2. High heat – 2100° F. (5¼ min. in the furnace).
3. Air cool to room temperature (see NOTE in opposite column).
4. Temper at 1000° F. (2 hr.), air cool.

Because of the extremely short time the steel is at the quenching temperature, one can heat treat tools of high-carbon high-chromium steel by this method in ordinary fuel-fired furnaces without encountering excessive decarburization or soft skin. Normal grinding operations to remove scale and produce a smooth surface will serve to remove the slight amount of decarburization, just as in conventional heat treatment of high speed steel.

Dimensional Changes (Distortion) – An investigation of dimensional changes resulting from the newly developed treatment was necessary because it is known that treatments which produce large amounts of austenite cause contraction of volume (and dimensions).

To determine the facts a 2-in. cube was machined from annealed bar stock and was smooth ground. Dimensions were carefully measured and specific gravity was determined. The cube was then heat treated as follows:

1. Preheat – 1500° F. (1 hr. at heat).
2. High heat – 2100° F. (10 min. in furnace).
3. Air cool to room temperature.

After remeasurement of dimensions, specific gravity was determined in the as-quenched condition. Then the cube was successively tempered at intervals from 900 to 1050° F. and was checked for dimensions and specific gravity after each temper. See Table III.

This shows that initially a large amount of contraction occurs in the quench. However, when tools are tempered to the conventional hardness (at 1000° F.) the contraction will be decreased to a tolerable amount (0.001 in. per in.). If greater dimensional precision is required, zero size change on any one dimension results from retempering at small increments above 1000° F. Based on the above data, this condition would be reached between 1000 and 1020° F. Further details about this method (called the "austenite-martensite balance method") of obtaining zero distortion are given in articles by the present author entitled "Distortion of Tool Steel in Heat Treatment" (*Metal Treating*, July-August and Sept.-Oct. 1951).

Service Tests – To determine the effect of this short-time high speed steel type of heat treatment on tool life, we made service trials on trimmer dies for cold trimming alloy steel forgings. These dies are subjected to some shock loading as well as wear on the cutting

NOTE: It is generally recommended that tools should not be cooled in the quench all the way down to room temperature, but should be removed from the quench while warm and tempered immediately. However, because of the relatively large amounts of stable austenite produced by the cycle above specified, it is safe to cool tools treated by this method all the way down to room temperature. Tempering can be done when convenient but should not be delayed unnecessarily.

Table III – Specific Gravity Vs. Tempering Temperature

	Specific Gravity	Change Specific Gravity	Average Change in 2-In. Dimensions
As annealed	7.71	–	–
As quenched, 2100° F.	7.82	+1.4%	−0.004 in./in.
Tempered 900° F.	7.82	+1.4	−0.004
Re-tempered 950° F.	7.82	+1.4	−0.004
Re-tempered 980° F.	7.79	+1.0	−0.003
Re-tempered 1000° F.	7.74	+0.4	−0.001
Re-tempered 1020° F.	7.70	−0.1	+0.0005
Re-tempered 1050° F.	7.68	−0.4	+0.001

Tests on Trimmed Forgings

edges. Forgings were selected which could be readily measured with a micrometer, as a means of evaluating die wear. The test tools were composite dies made up from assembled sections which enabled us to compare sections treated in different ways.

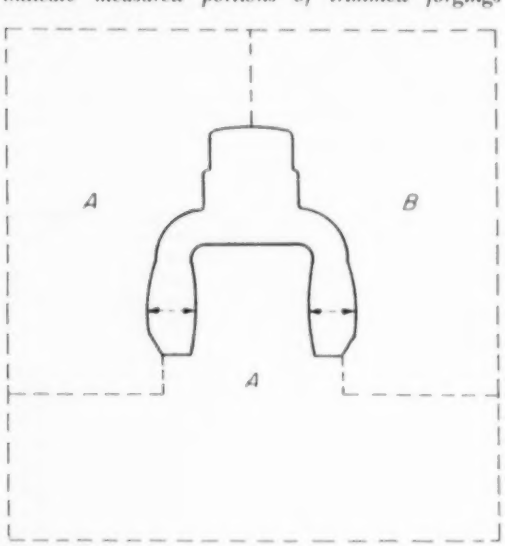
Figure 1 shows design of one of the test dies, a three-piece composite die. Sections marked A were made of high-carbon high-chromium toolsteel pack hardened in the conventional manner from 1850° F. The die section marked B was treated by the new short cycle from 2100° F.; arrows indicate the sections measured with a micrometer.

Figure 2 shows the design of the second test die, a four-piece composite die. Die sections marked A and A-1 were given the conventional treatment from 1850° F.; die sections B and B-1 were given the short-time 2100° F. treatment. The arrows show where micrometer measurements were made to indicate comparative wear of the sections treated by different methods. (See also photograph on page 67.)

The test dies were placed in service under normal conditions. Four test forgings from the regular run were measured after every lot of 500 forgings had been trimmed, to detect progressive die wear as it occurred in service.

A total of 5500 forgings was trimmed on the trimmer shown in Fig. 1 and 22,500 forgings were trimmed with the trimmer shown in Fig. 2. The voluminous data obtained from these tests cannot be reproduced here. However, the trend may be summarized as follows:

Fig. 1 – Three-Piece Trimmer Die Used for Service Test. A – pack hardened; B – short cycle. Arrows indicate measured portions of trimmed forgings



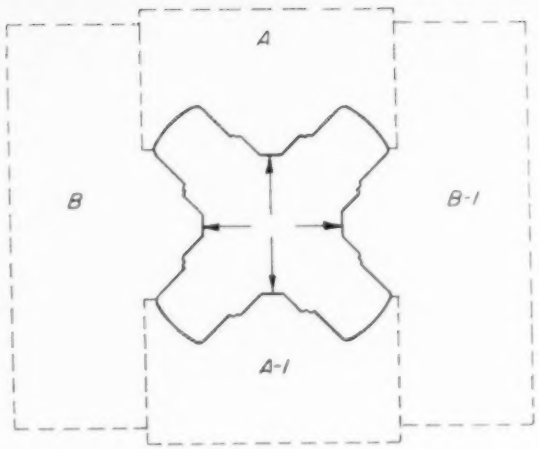


Fig. 2 – Four-Piece Trimmer Die Wherein Portions A and A-1 Were Hardened Conventionally From 1850° F., Whereas Portions B and B-1 Were Hardened by the Recommended Short Cycle From 2100° F.

Three-piece die (Fig. 1) – After trimming 5000 forgings, the leg size of forgings trimmed with the conventionally treated trimmers increased 0.013 in. as a result of wear. The comparison leg (trimmed on one side with a conventionally treated trimmer and on the other side with a trimmer having the special 2100° F. treatment) increased only 0.010 in.

Four-piece die (Fig. 2) – After trimming approximately 20,000 forgings, the increase of size due to wear of the trimmers was 0.012 in. on the trimmers treated by conventional methods but was only 0.006 in. on the trimmers treated with the new 2100° F. cycle.

These service tests were made primarily to determine whether tools treated by the newly developed method would safely withstand normal service stresses. It was an unexpected result that the wear resistance would be improved by the new treatment, and the service tests run to date have been too meager to predict the amount of improvement in wear resistance to be expected. At least, they indicate that tools thus treated can be safely used in service.

Summary – A practical short-time cycle for hardening high-carbon high-chromium toolsteel has been developed, similar to that used for high speed steel, in that austenitization is accomplished by heating for a short time at a relatively high temperature. Service tests made on tools treated by this method have performed well in service and show promise of having improved wear resistance.

The High Top-Pressure Blast Furnace

By E. L. PEPPER, Arthur D. Little, Inc., Cambridge, Mass.

UNDOUBTEDLY one of the most important developments in recent years in the steel industry is the operation of the so-called high top-pressure blast furnace. The idea was set forth by Julian Avery, a chemical engineer with Arthur D. Little, Inc., in U. S. patent No. 2,131,031 issued in 1938. His theory was that putting a blast furnace under increased static pressure by means of a throttling valve in the discharge gas main would reduce the velocity of the reducing gases through the furnace and thus result in better contact between solids in the charge and the reducing gas. Avery based his theory that operation of blast furnaces at higher top-pressures would be more efficient on the fact that the longer time of gas-solid contact would increase the amount of gaseous reduction of iron oxides by carbon monoxide and thus minimize the direct reduction of iron oxides by solid carbon. Since direct reduction absorbs heat rather than liberating heat (as is the case with gaseous reduction), the less the direct reduction the more efficient the blast furnace becomes. Direct reduction in blast furnaces, as operated in the United States, consumes on the average about 15% of the coke used in iron making. This amounts to a total of almost 300 lb. of coke for every ton of pig iron produced.

Although the theory was set forth in the late 1930's it was not until the wartime demand for pig iron reached its peak that a furnace was actually operated at top pressures substantially above normal. This trial was carried out in 1944 by Republic Steel Corp. on Defense Plant Corp.'s No. 5 furnace in Cleveland under the sponsorship of the War Metallurgy Committee, and under personal supervision of the late Joseph H. Slater of the steel company's operating staff. Mechanical difficulties were encountered after four months of operation at 10-psi. (gage) top-pressure, and it became necessary to revert to conventional operations, but the results were sufficiently promising to convince the Republic staff that further trials were warranted. Accordingly, two Republic blast furnaces were converted for pressure (Cleveland No. 5 and Youngstown No. 3) and operation in the range of 10 to 12 psi. (gage) commenced in the summer of 1946. This time mechanical difficulties were overcome by design changes, with the result that lost time on the high top-pressure furnaces is now no greater than on most normal pressure furnaces.

The increase in iron tonnage, decrease in coke and flue dust rates, and resultant lower manufacturing cost of pig iron have resulted in the conversion or construction of more than 20 high top-pressure blast furnaces throughout the world. At least six and probably more are operating in the Soviet Union. At the present time there is one furnace operating in Great Britain and two new furnaces are being built as pressure furnaces.

The theory of Avery has been proven by performance of the several pressure furnaces over the past six years. Because of limitations of physical equipment it has been impossible to operate any of the existing furnaces at top pressures above 12 psi. (gage), and the benefits have been, primarily, increased iron tonnage and decreased flue dust production. When a furnace now under construction in England designed for operation at top pressures of 20

Pressure Furnaces Save Coke . . .

psi. (gage) is in blast, it is expected that a substantial amount of coke will be saved.

It should be pointed out that the demand for pig iron in the United States since 1946 has been such that the wind volume on all the pressure furnaces has been increased along with top pressure. As a result no large coke savings have been apparent for any extended period of time. There have been short periods of operation where coke savings have been made when, for one reason or another, the wind volume has not been increased proportionately with the top pressure.

Perhaps the best coke economies have been obtained on the Colvilles' furnace in Glasgow, Scotland, and Republic Steel Corp.'s No. 2 furnace in Buffalo.

For a period of six months the Colvilles' pressure furnace, while producing 11% more pig iron than a sister furnace operating on normal top-pressure, had a coke rate 70 lb. per ton less than the normal furnace. During this six-month period the two furnaces used the same raw materials. Operation of the same two furnaces for 18 months prior to pressurizing No. 2 resulted in nearly equivalent coke rates, with No. 2 consuming 20 lb. less per ton of iron. Thus it is quite evident that a coke saving can be made by pressurizing, even while producing more pig iron.

The Buffalo pressure furnace of Republic Steel Corp. has consistently produced 10% more iron at a slightly lower coke rate than during the two years prior to pressure operation. For the past six months the coke rate on this furnace has been 100 lb. per ton less than it was during the two-year period before pressure operation. This has been achieved in spite of a decline in quality of raw materials, plus the fact that the furnace is continuing to produce 10% more iron than when it was operated on normal top-pressure.

Although there is not too much evidence supporting claims that substantial coke savings are possible with increased top-pressure, it is obvious that iron production can be increased 10% or more at no increase in coke rate. It is common knowledge that, in order to increase production of a normal top-pressure furnace by an equivalent amount, it would be necessary to make considerable sacrifices in coke economy as well as accepting increased flue dust production and irregular stock movement. (Flue dust on both the Colvilles' furnace and the Buffalo furnace has been reduced by 50%.)

The application of top pressure to the blast furnace gives the operator a new and valuable means of control; it permits him to adjust the velocity of the reducing gases through the stock column by other means than by altering the blast volume. If it is desirable to maximize iron production, the wind volume is increased along with the top pressure and the same gas velocity maintained. On the contrary, if coke and flue dust savings are of paramount importance, the same wind rate can be maintained with lower gas velocities than are possible on normal pressure and thus the same iron tonnage will be produced at lower coke and flue dust rates. The furnace also can be operated at some intermediate point and more iron made at a lower coke rate and with less flue dust.

In times of strong demand for pig iron (as in this country for the past decade) the blast furnace is generally crowded close to its upper limit, which is usually determined by stock movement and flue dust production. While it is true that iron production increases as a straight-line function with wind blown, there is a point beyond which it becomes uneconomical to blow the furnace any harder, for the amount of the flue dust carried out at high wind volumes becomes excessive, and the stock in the furnace will descend irregularly. Thus, the limiting factor governing the amount of iron that can be produced with a given burden is the amount of air that the furnace can accept without producing excessive quantities of dust.

Another factor that has limited iron production in recent years is the quality of raw materials available for the blast furnace. Ores are finer in particle size and consequently more susceptible to dusting as well as being lower in iron content. In addition, coke has deteriorated in both physical and chemical properties. Various steps have been taken to offset this downward trend in quality of raw materials, but these are expensive and add considerably to the cost of pig iron.

On the other hand, it is possible to pressurize a blast furnace and thus increase its capacity for a capital investment of about $200,000, provided adequate blowing capacity is available. Most blast furnaces built within the past 15 years have adequate blowing capacity. In addition, a number of older furnaces have been equipped with new turbo-blowers large enough to permit operation in the range of 10 psi. (gage) top-pressure. Even though new blowing equipment may be necessary, the cost is not prohibitive when one considers that furnace output can be increased by 15% or more.

It has been found that top-pressure furnaces can accept inferior raw materials with less effect upon production rate. For example, it is possible to charge more than 200 lb. of raw flue dust per ton of iron without adversely affecting furnace performance. As a matter of fact, dust production has been markedly less than on normal pressure furnaces, even when raw flue dust was being charged. Since sintering of flue dust is a rather expensive operation, the ability of a pressure furnace to accept even limited amounts of raw flue dust means a saving in the manufacturing cost of pig iron.

It has also been found by experience that a pressure furnace can utilize beehive and other inferior grades of metallurgical coke, which so frequently must be used in these days of shortages, with little if any effect upon furnace output. The Youngstown pressure furnace of Republic Steel Corp. has used mixtures containing as many as 14 different purchased cokes at the same time without any significant alteration in furnace behavior becoming apparent. When these same cokes have been used on normal furnaces they have adversely affected iron production, coke and flue dust rates. When the Colvilles' sinter plant was shut down for a brief period it was apparent that the use of unsintered material had much less effect on the pressure furnace than on the normal furnace. This ability of a pressure furnace to utilize lower-quality raw materials is becoming increasingly important as our domestic supply of high-grade blast furnace ores and coke is being rapidly depleted.

Operation of a blast furnace at top pressures less than 5 psi. (gage) does very little good. Slight decreases in flue dust production and correspondingly higher yields are noted, but little if any increase in output can be expected. Since the average gas velocity through the stock column of the blast furnace is dependent upon the absolute pressure, it is apparent that in order to decrease the velocity enough to make possible significant increases in wind volume or decreases in flue dust and coke rates it is necessary to raise the top pressure well above 5 psi. (gage). For example, on a large modern blast furnace using lake ores, the normal top-pressure is between 2 and 3 psi. (gage) and the average gas velocity through the stock column is about 70 ft. per sec. Increasing the top pressure to 5 psi. (gage) reduces the average gas velocity through the furnace stock column to about 63 ft. per sec., equivalent to a 10% reduction. At 7½ psi. (gage) the average velocity would be about 58 ft. per sec., and at 10 psi. (gage) about 53.5 ft. per sec. – decreases of 17 and 23.5% respectively. These calculations on average gas velocities indicate that for substantial increases in wind volume, top pressures should be as high as possible.

The reduction in gas velocity brought about by the increased top-pressure results in less flue dust being carried out of the furnace by the off gases. As the velocity of the gases in the free space above the furnace stock column is reduced, the amount of fine material (particularly iron ore) that is actually swept out of the furnace into the gas-cleaning equipment is reduced. Increasing the average static pressure, and thereby reducing the pressure drop through the stock column, results in more uniform gas distribution across the furnace and lessens the amount of channeling and irregular stock movement. Since these factors determine to a large extent the quantity of fines in the gas as it enters the free space above the stock column, any improvement that can be made is reflected in a decrease in dust rate. The lower the dust content of the gases at the top of the furnace the less the carryover.

One disadvantage of pressure operation is that blowing against the higher pressure increases the amount of steam necessary for the turbo-blowers and thus adds to the blowing cost. Lost time on a pressure blast furnace will probably be higher than normal for the first few months of operation, but once the operators become accustomed to the new equipment, lost time should drop to a level comparable to that of a normal furnace. It is important that gas leaks be repaired immediately, since at higher pressures these will enlarge very rapidly. It is necessary to add to the ordinary blast furnace a number of mechanical modifications in order that the furnace can be operated at elevated pressures. On a modern furnace the cost of these alterations amounts to about $200,000 at present prices.

In summary, the operation of the blast furnace at elevated top-pressures offers an easy and economical way to increase pig iron production, decrease flue dust rate and thus reduce the manufacturing cost of pig iron. Under certain conditions it appears possible to save coke. Certainly more wind can be blown and more iron produced than on normal pressure at little or no increase in coke rate. In addition, pressure operation enables the furnace to utilize lower-quality raw materials and provides the operator with a measure of control over the furnace not otherwise obtainable.

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Stress-Corrosion Cracking of Commercially Pure Titanium

TO THE BEST of our knowledge there are no references in the literature indicating that titanium is susceptible to stress-corrosion cracking. Commercially pure titanium has excellent resistance to corrosion in a wide range of mediums but, in common with most commercial metals, this resistance to attack is not inherent but associated with a protective surface. Metals of this type are usually susceptible to stress-corrosion cracking under some conditions because any break in the continuity of the surface film provides a port of entry for the corroding medium. In addition, titanium has comparatively high yield strength and can carry high elastic stresses which also favor stress-corrosion cracking. It would therefore be quite unexpected if titanium proved to be immune.

The lack of positive data on this phenomenon may be due in part to the fact that laboratory tests indicate the surface condition of titanium to be very stable in favorable environments; thus, a severe combination of stress and corrosion may be required to produce cracking. The tendency for titanium to creep at the moderately elevated testing temperatures may also have some influence, particularly when the test methods employ a constant deflection rather than a constant load, and unless cracking occurs quite rapidly, the applied stress will gradually diminish by relaxation and fall below a minimum required to cause failure. The results of our tests to date indicate that high stress in a particularly selective environment may be necessary to produce stress-corrosion cracking in titanium by laboratory techniques.

While some tests were carried out in this investigation using methods whereby the applied load was constant, the results now reported are purely qualitative and were part of a search to find a corroding medium which would stress-crack the metal in a short time.

The material was commercially pure titanium (Titanium Metal Corp. Alloy 75A) from several different melts. The carbon content ranged from 0.01 to 0.04%, silicon from 0.04 to 0.05%, nitrogen from 0.02 to 0.04%, tungsten from 0.01 to 0.04%, iron approximately 0.10%, and smaller amounts of other residuals.

The samples were taken from 0.035-in. sheet in the annealed state. The sheets were sheared into samples 1 in. wide by 4 in. long, and all edges ground. The samples were bent over a die to a shape like a horseshoe, acquiring a uniform permanent set and the ends then pressed together and forced into a titanium channel of uniform width. This method resulted in a deflection which produced an original stress transverse to the rolling direction, probably near the yield strength of the metal.

In addition to these horseshoe tests, Erichsen cup tests were also used. Again, the results are merely qualitative, as all of the samples were indented to within 1 mm. of breaking.

The horseshoe samples, along with an occasional Erichsen cup test, were immersed in many chemical solutions, particularly those which are known to produce stress-corrosion cracking in other metals. No cracking occurred even after several weeks' exposure in the solutions listed in Table I.

The reagents noted in the table constitute a wide variety of corrosive mediums, including

Fig. 1 – Horseshoe Sample Showing Type of Cracking in Red Fuming Nitric Acid. 2 ×

Fig. 2 – Erichsen Cup Test After Exposure in Red Fuming Nitric Acid. 1½ ×

many which are standard solutions used for stress-corrosion testing of other metals. The resistance of highly stressed titanium to cracking in these solutions provides a good indication of its value as a material of construction. Its general corrosion resistance in chloride solutions is excellent, and its apparent resistance to stress-corrosion provides an advantage over some of the commonly used metals which are susceptible to such cracking. The behavior of titanium in the 20% ferric chloride solution is quite striking, as this reagent is a vicious pitting medium, and often a source of stress-corrosion failures. The application of titanium for fabricated chemical equipment appears most promising in view of these data.

CRACKING IN RED FUMING NITRIC ACID

One solution was found which produced cracks in stressed samples, and that is red fuming nitric acid at room temperature. The test samples were totally immersed and time for cracking varied between 3 and 16 hr. Samples exposed in the vapors alone also cracked after several weeks' exposure. The red fuming nitric acid was of reagent grade, sp.gr. 1.60, containing 20% NO_2. Figure 1 is a photograph of one of the cracked horseshoe samples and Fig. 2 is a slightly enlarged photograph of the cracks developed in the Erichsen cup test piece. Numerous cracks were also found around stencil marks on unstressed samples after they were immersed

Table I – Solutions Which Did Not Induce Stress-Corrosion Cracking in Titanium Under the Conditions Stated

20% Sodium chloride plus 1% ferric chloride, boiling
20% Sodium chloride plus 1% cupric chloride, boiling
20% Sodium chloride plus 1% silver chloride, boiling
20% Sodium chloride plus 1% nickel chloride, boiling
20% Sodium chloride plus 1% mercuric chloride, boiling
20% Sodium chloride plus mercurous chloride, saturated, boiling
20% Sodium chloride plus 1% zinc chloride, boiling
20% Sodium chloride plus 1% potassium permanganate, boiling
20% Sodium chloride plus 1% sodium dichromate, boiling
Saturated solution sodium chloride, boiling
20% Sodium chloride plus H_2SO_4, pH = 0.3, boiling
20% Sodium chloride plus H_2SO_4, pH = 1.5, boiling
20% Sodium chloride plus H_2SO_4, pH = 3.1, boiling
20% Sodium chloride plus 3% hydrogen peroxide, room temperature
20% Ferric chloride, room temperature
42% Magnesium chloride, boiling
20% Salt spray, 90 to 95° F.
Sea water (synthetic), room temperature
65% Nitric acid, boiling
10% Sodium hydroxide, room temperature
50% Nitric acid plus 5% copper sulphate, boiling
90% White fuming nitric acid, room temperature
Aqua regia, room temperature

for several weeks in the red fuming nitric acid.

Microscopic examination indicates that the cracking is intergranular. Figure 3 is a photomicrograph of a horseshoe sample in the initial stages of cracking, just before complete fracture occurred. Figure 4 shows cracks which developed around stencil marks on an otherwise unstressed sample, also of an intergranular nature, and quite wide. The beginning of further cracking is indicated by the heavy grain-boundary attack adjacent to the wide crack.

A limited number of tests were carried out to determine if the addition of some other chemicals to the red fuming acid might inhibit stress-corrosion cracking. Addition of 1% by weight of sodium bromide prevented cracking, even after several weeks' exposure. Tests are being continued to determine if it is effective for very long periods of time. It is also planned to determine the minimum addition required for effective inhibition.

It is interesting to note that cracking only occurs in red fuming nitric acid and not in boiling 65% nitric acid or white fuming nitric acid. The corrosion rates of unstressed titanium in these acids are as follows:

Boiling 65% nitric acid, 0.001 to 0.00015 in. penetration per month.

Red fuming nitric acid (totally immersed) at room temperature, 0.000,005 to 0.000,007 in. penetration per month.

White fuming nitric acid (totally immersed) at room temperature, insignificant after 14 weeks' exposure.

These corrosion rates do not appear to offer any clue as to why cracking is confined to the red fuming acid only. One might suppose that the higher corrosion rate in boiling 65% nitric acid is not sufficiently selective to cause localized attack; however, the low corrosion rate in the white fuming acid is thought to provide the necessary degree of selectivity, yet cracking does not occur. (There is a possibility that much longer periods of testing in the white fuming acid may produce cracking.)

The most significant difference in these three acids is the high percentage of nitrogen dioxide present in the red fuming acid. This acid is so unstable that many different oxides of nitrogen may exist in it, any one of which may cause attack. The inhibiting effect of the bromide is difficult to explain from the standpoint of chemistry, and is worth further investigation.

While the work completed to date is only qualitative, it will be continued and include some quantitative measurement of threshold stresses. The experiments are not easy to perform. Red fuming nitric acid is not only an unstable chemical but it also is hygroscopic and tests cannot be carried out in an open system. Our tests already completed have been conducted in a closed system which results in a slight pressure build-up. The glass equipment is painted to exclude light and some time is involved in dismantling for examination and reassembling. The testing of samples under a constant load is therefore quite complicated and proceeds slowly, but should prove valuable in future applications of titanium.

Fig. 3 – Photomicrograph of Cracks in Horseshoe Sample. Etched in HNO_3-HF; 500 ×

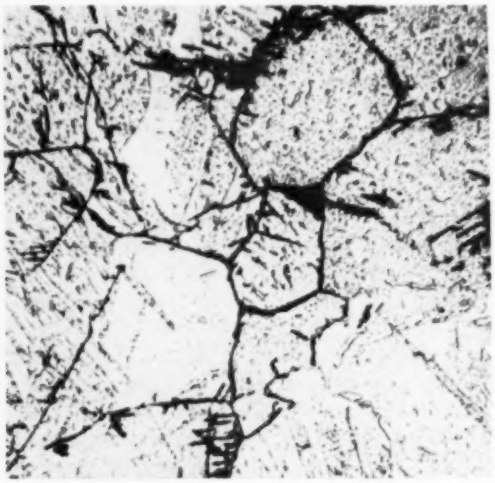
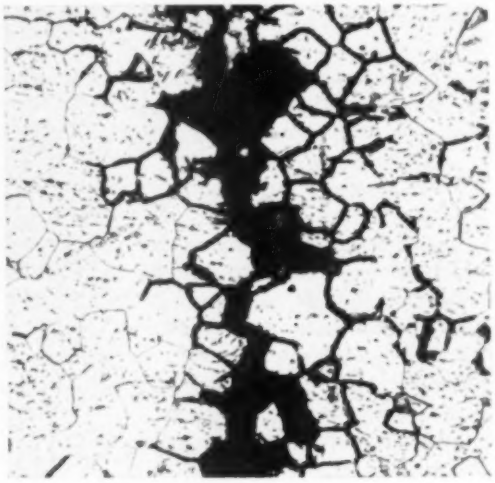


Fig. 4 – Photomicrograph of Cracks Around Stencil Marks in Unstressed Sample. Etched in HNO_3-HF; 250 ×



Spontaneous Combustion of Metal Powders

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INCREASING USAGE of fine metal powders has renewed interest in their pyrophoric property – that is to say, their ability to ignite spontaneously in air, frequently in an unpredictable manner. Although this behavior had been observed more than 100 years ago, the nature and substance of such materials have been more or less defined, and about 80 articles published on the problem in the past 40 years, an appreciable number of fires and burns still result from their handling.

The term pyrophoric includes materials of varying degrees of sensitivity, ranging from spontaneously ignitable in air at room temperature to inflammability at elevated temperatures. Although it is possible, in principle, to assign an ignition temperature for each type of powder – for example, this is 200° C. for zirconium prepared by calcium reduction – in practice statistics do not count, and such powder occasionally ignites at room temperature. Any pyrophoric powder, regardless of its ignition temperature or apparent stability, must be handled at all times as a potentially dangerous material. Pyrophoricity – quality or condition of pyrophoric nature – is markedly influenced by the extent of surface oxidation of the metal powder. It will diminish the longer the powder is exposed to air.

Since the time when the phenomenon was first described, several theories have been formulated to explain it, and have been expounded in the literature; they have attributed the behavior to the presence of a finely divided oxide, to an allotropic modification, to the presence of a metastable equilibrium, to heat capacity, or to thermal conductivity. These theories have become untenable in the light of present evidence. The consensus now attributes pyrophoric behavior to the fineness of division of the metal, and therefore to the amount of free surface of the powder. Despite the preponderance of evidence, a recent article in a German publication attributes pyrophoricity to the reaction between oxygen and hydrogen supposedly absorbed by the powder. It seems fairly certain that the presence of hydrogen will catalyze the oxidation of finely divided metal in air, but pyrophoric metal powders have been prepared without using hydrogen, and the pyrophoric properties of metal powders prepared in the presence of hydrogen remain after removal of the hydrogen by vacuum treatment. It is also of interest in this connection to note that the hydrides are less pyrophoric than their parent metals at the same particle size.

The degree of pyrophoricity is critically dependent on the particle size. Zirconium powder of average particle size of three microns is very pyrophoric, whereas zirconium powder of 12 microns does not catch fire at red heat. Uranium powder retains its pyrophoricity at larger particle sizes than zirconium. As a matter of fact, uranium is so much more pyrophoric than zirconium that, whereas zirconium powder is usually stored under water, uranium powder of the same particle size will catch fire under boiling water (and will generate enough heat to melt the glass container).

Considerably finer particle sizes are required to render iron, nickel or copper pyrophoric – about one hundredth the size of zirconium. It is generally true that the higher the heat of formation of the metal oxide, the larger the particle size may be and yet retain the ability to burn spontaneously. Pyrophoric action, then, results from the inability of a metal powder to dissipate its heat of oxidation (even slow oxidation) rapidly enough, thus causing its temperature to rise rapidly. The process can then be looked upon as a variety of the common thermit fuse, consisting of coarse particles of aluminum or magnesium mixed with potassium chlorate or barium dioxide, wherein the coarser particles of aluminum or magnesium are rendered

Preventing Fires From Metal Powders

pyrophoric by increasing the concentration of oxygen in contact with the metal. The large amounts of heat liberated during oxidation of a pyrophoric powder will cause an explosion if the powder is suspended in air as a dust.

Particle sizes of the order of 100 to 300 Angström units (0.01 to 0.03 micron) will make iron, nickel and copper pyrophoric. Their extreme sensitivity to oxidation may be gleaned from the fact that freshly prepared iron powder of this size will become quite warm to the touch, due to oxidation, even when confined in a flowing argon atmosphere whose dew point has been lowered to −70° F. Such iron powder, useful in making permanent magnets, shows a gradual deterioration in magnetic properties if it is stored as a loose powder in such an atmosphere.

Zirconium or sodium powders of this degree of fineness will catch fire immediately on exposure to the air. Thus, in the reduction of zirconium oxide by molten calcium in a protective argon atmosphere, some of the zirconium fines are carried out of the reaction crucible by the argon to other parts of the equipment; flash fires occur as soon as air is let into the system. Any reaction involving sodium at an elevated temperature will usually result in parts of the equipment becoming coated with dangerously inflammable sodium dust.

Since the amount of free surface available for oxidation is usually considered the criterion for pyrophoric tendencies, any process or condition which contracts this surface will of necessity result in some loss of pyrophoric properties. Sintering is such a process; it results in the agglomeration or fusion of the particles, and therefore reduces the amount of free surface available for oxidation. The extent or degree of sintering is highly dependent on the temperature employed in the preparation, so that low reduction temperatures favor pyrophoricity. Thus, nonpyrophoric tungsten metal powder, commercially prepared by hydrogen reduction of tungsten trioxide at 750 to 900° C. becomes so pyrophoric if prepared by slow reduction at 600 to 650° C. that the powder cannot be removed through the hydrogen flame at the furnace exit without igniting, even though it has been allowed to cool to room temperature in a cool end of the furnace prior to its removal. The particle size of such powder is about 1 micron. Somewhat similar conditions exist in iron powder prepared by the reduction of magnetite in hydrogen or an atmosphere rich in carbon monoxide. To avoid rapid reoxidation in storage, such powder should be heated, immediately after reduction, to 1200° C. (2200° F.).

A higher reduction temperature, to render pyrophoric materials safe, may be attained by adding impurities which prevent sintering of the particles during the process. The substance added is selected on the basis of the irreducibility of its oxide by hydrogen, and this effect has been known for over a century. This technique, which is called

Equipment for Mixing, Compounding and Screening Metallic Powders in the Manufacture of Compacts Is Completely Enclosed so That no Dust Escapes to the air. Screen in center is covered, and rubber ducts feed tightly into the sealed containers shown in the foreground. (Photo courtesy Amplex Mfg. Co.)

doping, has been applied to the preparation of ultrafine (on the order of 300 Angström units) iron powder suitable for permanent magnets, wherein the finer the particle size the better the magnetic quality. Such iron powder is usually prepared by the hydrogen reduction of ferrous formate at 325° C.; if the ferrous formate is recrystallized in the presence of calcium formate, some irreducible calcium oxide is formed during furnacing and prevents sintering of the metal powder simultaneously formed. The particle size of calcium oxide doped powder is at least 25% smaller than undoped powder prepared under identical conditions, and is of the order of 0.025 micron.

In manufacturing processes involving the use of fine metal powders, either controlled pyrophoricity is desired or it is accepted as a necessary evil accompanying other desirable properties. In the first category can be put zirconium powder used in the fuse of photoflash lamps, and nickel powder in the fuse of hand grenades. Examples in the second category are permanently magnetic iron powder and metal powder catalysts for a variety of organic reactions. In both classes the great danger of pyrophoric action lies in its unpredictability, and new methods of preventing or controlling ignition of such powders are being constantly developed.

Perhaps the simplest way of handling such hazardous powders is by collecting the powder after preparation under a liquid which is nonreactive and which can subsequently be removed without destroying the fineness or desirable properties of the powder. Nonpolar organic liquids, such as naphtha, benzene or hexane, are particularly suitable, although alcohol or acetone are occasionally used. These are all low boiling liquids. Water is used as the protective medium for pyrophoric zirconium used in photoflash lamps, and a thin, adherent protective oxide film on the metal's surface presumably passivates the material. It seems possible to store many pyrophoric powders under water for a few hours if the water has been carefully purified of its oxygen, but thorough removal of oxygen from the water is so tedious as to make this procedure unattractive.

Plastics or resins dissolved in solvents (such as polystyrene in benzene) may be utilized as protective coatings for the powder; after the solvent is removed, material so treated may be stored without fear of self-ignition. Such protective methods cannot be used, of course, when the surface properties of the powder are to be utilized, as in catalysts or flash powders.

Uses for Combustible Powders

Increasing use has been made of inert atmospheres, such as nitrogen or argon, as protective blankets. If the oxygen has been carefully removed from the gas by hot copper, and the water vapor by activated alumina or phosphorus pentoxide, these gases allow handling the powder "as is". For extremely pyrophoric powders, such as 0.03-micron iron or very fine zirconium, these gas atmospheres cannot be purified sufficiently to allow more than a few hours' exposure before measurable oxidation of the powders. "Dry boxes", the airtight containers through which the protective inert gas is allowed to flow, are usually equipped with sealed-in rubber gloves so the powder can be handled, weighed or packaged.

Pyrophoric action is not limited to powders of substantially pure metals but includes compounds as well as alloys. Pyrophoric behavior occurs in the lower oxides of iron, manganese and uranium, the hydrides of uranium and cerium, and the carbides and nitrides of uranium. One can predict that almost any alloy or compound will be pyrophoric if it is in fine enough particles and if its heat of oxidation is strongly exothermic.

Controlled sparking action, as used for cigarette lighters and other igniting purposes, is based upon the abrading of particles from any solid alloy which are pyrophoric if finely divided. Mischmetal, hardened with iron, is ordinarily used for this purpose. Pyrophoric properties of alloy powders of the rare earths have been observed in lanthanum-magnesium, lanthanum-lead, lanthanum-tin, and silver-thorium. There are other alloys which contain no cerium or its allied elements which have pyrophoric properties when abraded; among them are zirconium-tin, uranium-iron, and antimony-iron.

There are many ways of producing pyrophoric powders; the method is usually dictated by the ease or difficulty of reducing the metal from its compounds. Readily reducible metals (such as iron, copper, nickel, cobalt, or lead) are most easily prepared by hydrogen reduction of oxides, formates, carbonates or nitrates. The more difficultly reducible metals (such as manganese or uranium) can be prepared by amalgamation and subsequent removal of mercury by distillation. Alkali metal reduction of the halides is almost universally applicable. Carbonyl decomposition, arc disintegration, electrolysis and decomposition of hydrides are also useful for various materials.

By W. W. SIEG, President,
Titan Metal Mfg. Co., Bellefonte, Pa.

Securing a Competitive Position by Sound Engineering and Modern Equipment*

I AM NOT the first to point out that mining and metallurgical engineers have unusual responsibilities as citizens. Should any of you doubt this, consider for a moment the concise definition of engineering by Earl Stavely, assistant dean of Penn State Engineering School: "Engineering is the art, based principally upon mathematics and science, of utilizing the forces and materials of nature economically for the benefit of mankind," and, I might add, the influence of the mining and metallurgical engineer is of the "grass roots" type.

This basic influence for the benefit of mankind has been simply demonstrated by Paul M. Tyler, of the Bureau of Mineral Research of Rutgers University. He observes that 17,000 metal miners and workers in directly allied industries in a mining state such as Utah support not only their 43,000 wives and children but also 148,000 merchants, mechanics, doctors, lawyers, barbers and other professional trades and service people and their dependent families, in addition to 32,000 persons on farms who grow things for all these people to eat. In simpler terms, for every man engaged in the mining and allied industries of Utah, 2½ jobs were created in service industries and a total of 12 Utahans were thereby supported. He further stated that this 12:1 ratio, amazing as it may seem, would be boosted much higher if account were taken of derived employment in other states.

With this idea of basic importance well established, let me mention five things which you in this audience, as metallurgists and good citizens believing in our system of free competitive enterprise, can do to secure it from the attacks now coming – directly or indirectly – from many sources.

First, we must understand the economic nature of the area in which we work and be ever ready to explain how industry operates to the hundreds who never get directly exposed to a mine, mill or factory.

Second, we must take immediate steps to conserve our remaining natural resources.

Third, we must strive to expand mass purchasing power by increasing unit production and lowering unit production costs.

Fourth, we must be on the alert for control measures, both national and world-wide, which would have the effect of retarding our industrial expansion.

And fifth, we must, as metals engineers, keep before us the trends developing in competition between the metals and their effect on the national standard of living.

EXPANDING MASS PURCHASING POWER

I will now spend a little time elaborating the third obligation – first in general terms, and then telling you of some specific things Titan Metal Mfg. Co. has done toward meeting this obligation.

We must do our share in expanding mass purchasing power. This simply means:

1. Higher unit production, accompanied by:

*Portion of an address before the Penn State Chapter following the presentation of the David Ford McFarland Award. The award is made annually to a Penn State graduate who has distinguished himself in metallurgy.

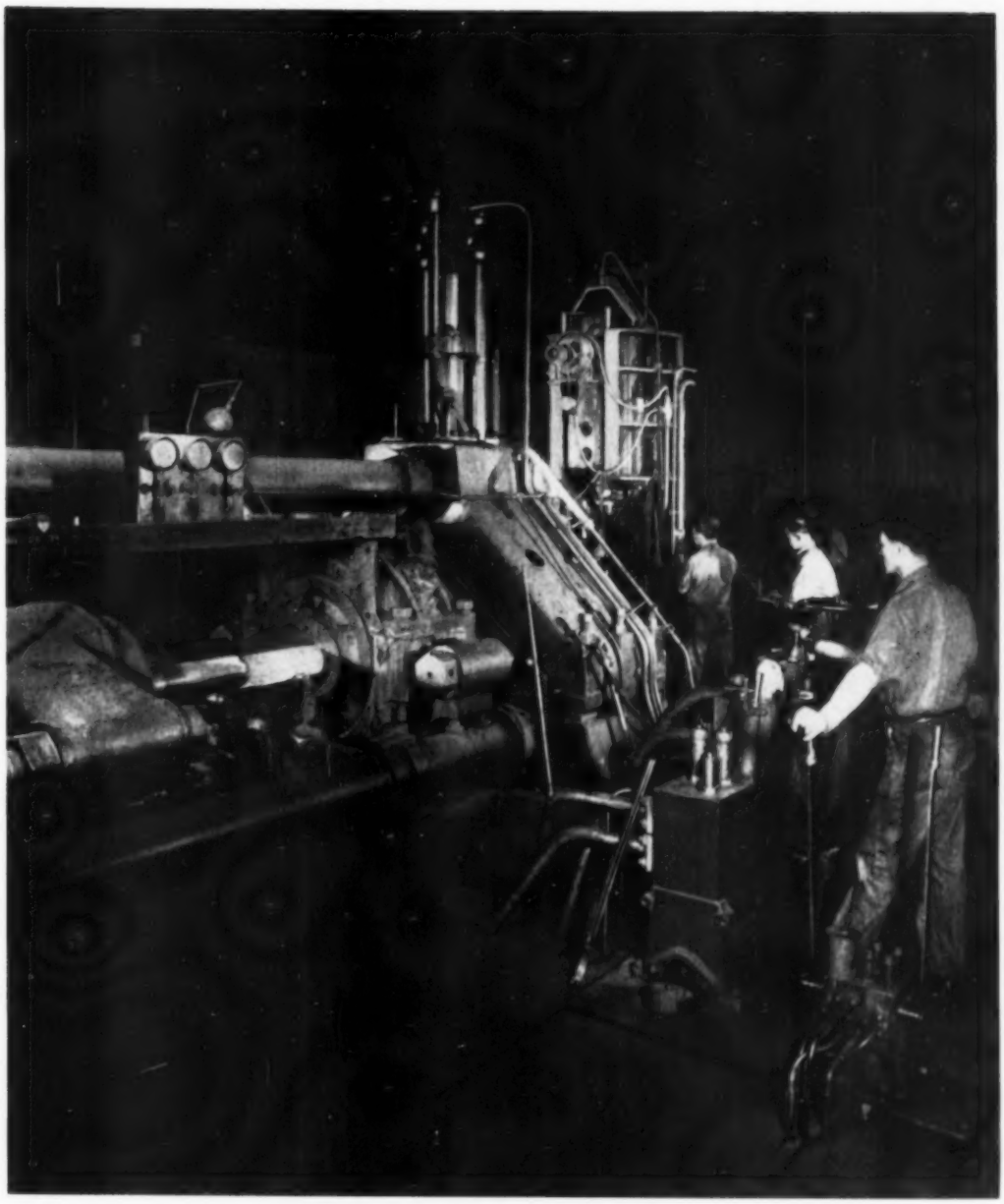


Fig. 1 – Extrusion Press of 2750 Tons Pressure at the Titan Plant for Forming Brass Billets Into Rods and Shapes

2. Better unit quality where possible, resulting in:

3. Lower unit costs, and the savings distributed as follows:

4. Increased employee income,

5. Lower unit selling price to the consumer,

6. Increased earnings to owners,

7. Sufficient money reinvested to remain competitive and to insure growth.

There is no other way to do this under our system of government.

I hope, now, that you will forgive me for referring to some of the more important technical developments which have enabled our company to increase its production nearly 23-fold since 1930 in the highly competitive brass mill products industry.

1. Melting raw materials in electric induc-

tion-type furnaces permitted the use of various types of copper and brass scrap which could not be handled in the crucible type of furnace.

2. Automatic temperature controls on all heating furnaces – for extrusion, annealing, forging – reduced the number of rejects and enabled us to produce brass products from alloys with narrow hot working limits.

3. Hot extrusion, hot pressing or forging, and hot pressure die casting of brass demand the ultimate in heat and wear resistant steel dies. Mechanical shock and thermal shock put them in constant danger. Unlike steel forgings, brass forgings are produced to very close tolerances and it is not unusual for a set of dies to cost several thousand dollars. Under these circumstances, the best in steel and the best in heat treating furnaces prove to be the most economical in the long run. Heat treatment of the steel die is, of course, most important and close control is desired. Thus the economics of many of our processes are tied very closely to the ferrous metallurgist in the toolsteel mill. He is providing the brass producer with die steels and toolsteels which give greater service. We look for further help from him. In fact, the full utilization of the brass die-casting process is waiting for better hot work die steels.

4. What is true of the hot working processes is largely true of the cold working processes, such as the cold drawing to size of brass rod and the forming by machining on turret lathes, automatic screw machines, drill presses, milling machines, automatic chuckers and tapping machines. Here, full utilization of cemented tungsten carbide drawing dies and forming tools has greatly increased production, reduced costs, and given the consumer a higher quality product. The introduction of cemented carbides, however, was accompanied by a great amount of grief. They were originally used for the machining of cast iron – a relatively easy material to machine. Gradually, several grades of carbide became available to meet various conditions of shock, abrasion and cutting of metals of difficult analysis – but it was not until the machine tool industry completely redesigned its tools to provide sufficient speed and rigidity that carbide cutting tools could be fully utilized. This changeover took many years. Even today, many machine tools are in use which were built at a time when tungsten or tantalum carbide was unknown. Such a radical metallurgical development points up the need by industry to preserve a portion of its earnings so as to meet these almost mandatory demands for new equipment.

5. Utilization of the highest quality of metallurgical refractories.

6. Adapting the best heat resisting alloys in production operations, such as metal skimming bars, furnace rails, slug heating trays, die-casting furnace crucibles, and so on.

7. The success of many metalworking processes is dependent on the proper lubricant. We have been fortunate in securing maximum cooperation between our metallurgical department and petroleum technicians in solving many fabricating problems. Here, also, many improvements are coming which promise to double (and possibly quadruple) the productivity of cutting tools.

8. The latest scientific device to be used by our company is the direct-reading quantitative spectroscope for checking the analysis of heats. To speed the operation, we have installed a pneumatic tube system to deliver brass samples from the casting shop to the laboratory. The speed of this method of analysis also makes it practical to analyze scrap materials which otherwise might be rejected. It enables us to utilize good scrap in the production of high-grade brass mill products and, thereby, further conserves the available supply of virgin raw materials.

I have stressed the importance of some of the metallurgical advances which have gone into the building of an industry, but would be amiss if I were to imply that these were the only factors in a company's expansion. Mechanical, electrical, chemical and industrial engineering have had a most important share. After the work is planned, the operations have to be carried on by skilled and semiskilled workers, and the degree of progress that a company makes is directly related to the manner in which management has utilized the tools at its disposal – such as incentive wage plans built on sound time and motion study, job evaluation and classification, hourly wage and salary plans which reward the most capable employees within a wage bracket, employee training courses including both skilled workers and employee supervisors, good procurement, production and cost control techniques. Finally comes an aggressive sales program in which the metals engineer is a growing factor because of the intricate problems encountered by our customers and their ever-growing demands for high-quality products to meet exacting requirements. All this necessitates the maintenance of excellent customer relationships.

Commercial Power From Uranium

SEMI-ANNUAL reports of the U. S. Atomic Energy Commission have mentioned the reactors built or being built by its various contractors, but descriptions have been very meager. Principal data on 16 American reactors and four foreign are given in "Engineering Principles and Metal Requirements for Atomic Power Plants", by W. J. Koshuba and V. P. Calkins in *Metal Progress*, July 1952, p. 106.

Some constructional details about the first reactor to produce power – enough for its own operation *plus* an excess – have been given* by Alfonso Tammaro, Manager of Chicago Operations Office, U.S.A.E.C. This is the Experimental Breeder Reactor (EBR) at National Reactor Testing Station near Arco, Idaho.†

Although EBR generates significant quantities of electricity, it was not built primarily for that purpose, but to demonstate and study the possibility of "breeding" – that is, the production in a reactor of more atoms of plutonium [fissionable metal which can also be used as a fuel] than the atoms of U_{235} which are used up in continuing the process.

The EBR began operation in August 1951. On Dec. 20, 1951, the world's first production of significant amounts of electricity from a nuclear reactor heat source was achieved when four incandescent bulbs were lighted. The following day, the external electrical supply to the building was disconnected and the entire power load was carried by the reactor-boiler-turbine-generator system.

The heat energy is removed from the reactor by liquid sodium-potassium alloy at about 625° F. Superheated steam at 400-psi. pressure is generated with this. The power required to operate the reactor's auxiliaries is approximately 85 kw. Excess power from the 250-kw. turbo-generator is used for building service, shop tools, or dissipated through resistors.

The reactor core – that is, the section of the machine containing the fuel – is approximately the size of a regulation football. Electromagnetic pumps and flow meters are used in the liquid metal circuits.

Surrounding this small central core is a breeding blanket which consists of natural uranium [metal, originally 90.3% U_{238} and 0.7% U_{235}]. The material in this blanket, like the fuel, is suspended in the sodium-potassium coolant in a cylindrical tank. Since the EBR operates on high-energy neutrons, no moderating material is contained in the tank to decrease their energy.

Surrounding this tank is material that reflects neutrons back into the reactor that would otherwise escape and be lost. Surrounding all is a lead and concrete shield.

Sodium-potassium alloy was chosen as the coolant because of its low melting point, high boiling point, high specific heat, nonmoderating properties, and because its corrosive nature is modest compared to other suitable liquid metals. A low melting point prevents freezing of the coolant in the system during short shut-downs. A high boiling point eliminates the need for a pressurized system. The high specific heat is required because of the great quantities of heat generated in a small volume that must be removed as rapidly as possible. A material that does not possess moderating properties [does not slow down or capture neutrons] is essential since this type of reactor operates most efficiently in the very fast neutron range. The heat available from nuclear fuel is limited only by the temperatures that the fuel and structural material can withstand and the rate at which thermal units can be removed from the system.

The principal disadvantage of sodium-potassium alloy is its violent reaction with water or air.

In flowing through the reactor, the coolant becomes radioactive, so the entire primary coolant system must be shielded. A secondary sodium-potassium system removes the heat from this shielded heat exchanger and carries it out to a secondary heat exchanger. The secondary coolant is not radioactive; steam is produced in the secondary heat exchanger and flows through the turbo-generator system to produce electricity.

There are three major factors to bear in mind in considering the economics of nuclear power: *(a)* Plutonium can be produced concurrently, a vital material for atomic weapons. Power can now be produced from nuclear sources at competitive cost if plutonium can be sold to the Government for military purposes. There is probably no device so readily adaptable to both peace and war as a nuclear reactor.

(b) The economics in these early stages should not discourage interest.

(c) Cost is not the only parameter involved in areas remote from coal, oil, or gas.

I feel it is entirely feasible and possible to design and construct a nuclear plant which will produce power and plutonium simultaneously and at competitive prices.

*"Industrial Applications of Nuclear Energy", paper read before the American Society of Mechanical Engineers, Chicago, Sept. 8, 1952.

†From here on, the text is verbatim extracts from Mr. Tammaro's paper, except words enclosed in brackets [ ].

By ALLEN G. GRAY
Cleveland, Ohio

Alkaline Cleaning for Metal Finishing

THOROUGH cleaning is important in the successful use of any finishing system, since the presence of grease, dirt, and extraneous materials affects the adherence and continuity of metallic and organic coatings. The type of cleaner and cleaning cycle used must be suited to the condition of the metal surface and to the degree of cleanliness required. Among the oldest and the most widely used commercial cleaners are the alkaline types. In current practice these are employed as soak, electrolytic, or spray cleaners.

Detergency (the ability to clean a metal surface) results from many factors, one of the most important of which is low interfacial tension between the cleaning solution and the metal being cleaned. This low interfacial tension enables the cleaning solution to undermine the dirt and to break it up into fine globules that can be lifted away from the surface. Other factors, such as deflocculation, saponification and emulsification also play a part in the cleaning action.

The most commonly used alkalis for metal cleaning are sodium hydroxide (caustic soda), sodium metasilicate, trisodium phosphate, sodium sesquisilicate, sodium orthosilicate, tetrasodium pyrophosphate, and sodium carbonate (soda ash). Sodium hydroxide solutions have rather poor detergency unless the product to be removed is easily saponified. However, it serves as a good reservoir of alkali, and small quantities are sufficient to raise the pH of cleaners to the level needed for good detergency. In general, the milder alkalis, such as sodium metasilicate and tetrasodium pyrophosphate, have higher detergent ability than sodium hydroxide.

The American Electroplaters' Society has recently conducted a comprehensive investigation on cleaning and preparation of metals for electroplating (Research Project No. 12). One phase of this study was concerned with selection of suitable cleaner formulations. Table I summarizes formulations given in the report for soak cleaning solutions (nonelectrolytic) for steel; Table II gives compositions of representative electrolytic alkaline cleaning solutions.

One important point brought out in this research is that in comparing various alkalis with one another, it should be kept in mind that total available akalinity is relatively unimportant; what must be considered is the total active alkalinity, that is, the amount of alkalinity which is available above pH 8. One quick way of obtaining this information is to titrate to the phenolphthalein end point (pH 8.3) for total active alkalinity, and to the methyl orange end point (pH 4.5) for total available alkalinity.

Such a test will show that nearly all the silicate alkalinity is active. The silicates are good buffers and have wetting, emulsifying, and deflocculating properties. They have fair rinsibility, being better in this respect than soda ash at high temperature and worse at room temperature. The orthophosphates exhibit buffer action, show wetting and emulsifying properties and aid the action of soap. Also, these compounds have excellent rinsibility. The pyrophosphates and complex phosphates prevent the formation of hard-water scale on the work being cleaned. Pyrophosphates are also good detergents in their own right.

Soap and synthetic detergent compounds are

added to most alkaline cleaners to decrease surface tension and interfacial tension against oil. They emulsify oil and suspend solid particles of dirt in the solution. The addition of an alkali to soap solutions increases their surface tension but greatly decreases their interfacial tension against oils. In recent years, synthetic detergents have risen in importance as additives for cleaning baths.

Soak Tank Cleaners – In soak cleaning, the work is immersed in the cleaning solution for as long a period of time as is required. The bath is usually kept at or near the boiling point. Temperature has a marked effect on the detergent action of cleaning solutions. At a recent meeting of the American Hot Dip Galvanizers Assoc., G. A. Lux of Oakite Products, Inc., presented data to show that for every increase of 20° F. in the temperature of a cleaning solution above 140° F., the cleaning time is decreased 50%. Thus, if at 140° F., cleaning time is 40 min., at 160° F. it will be 20 min., while at 200° F. it will be reduced to 5 min.

Stirring need not be provided where boiling produces sufficient agitation. Other common methods of agitating soak-tank solutions are by use of agitation shields, steam-jet heaters, circulator heaters, pumps, and work movement. Various means are provided for avoiding recontamination of the work when it is being removed from the bath. The top of the bath may be skimmed off periodically, an overflow tank may be used, or baffles may be provided. Another important detail of tank construction is to allow the sludge to settle at the bottom away from the parts. Where work is quite dirty, a two-tank system may be of value. Most of the dirt is removed in the first tank, while final cleaning is done in the second tank. Figure 1 shows the design of a soak-tank cleaner equipped with an agitation shield and overflow dam.

Electrolytic Cleaners – Alkaline compositions are widely used for cleaning of metals by making the metal either anodic or cathodic. In anodic cleaning, oxygen gas is evolved, causing increased agitation directly at the metal-oil interface and effectively increasing the cleaning action. In cathodic cleaning, generally spoken of as direct-current cleaning, the part is negatively charged and hydrogen gas is evolved.

One advantage of cathodic cleaning is that

Table II – Representative Alkaline Solutions for Anodic Cleaning of Steel*

Constituent	Weight Per Cent for Formulation Number Indicated					
	1	2	3	4	5	6
$Na_3PO_4 \cdot 12H_2O$	35			55	25	10
$Na_4P_2O_7$	5	9				5
$Na_2SiO_3 \cdot 5H_2O$	50	35				12
Na_4SiO_4			50			
Na_2CO_3			20	35	55	
NaOH	8	55	28	10	20	70
Wetting agent	2	1	2			3
Concentration in bath (oz. per gal.)	6 to 12	6 to 12	6 to 18	2 to 6	2 to 6	
Temperature of operation, °F.	175 to 210		200 to 220			
Current density (amp. per sq.ft.)	50 to 100		60 to 100			

Table I – Representative Alkaline Solutions for Soak-Tank Cleaning of Steel*

Constituent	Weight Per Cent for Formulation Number Indicated									
	1	2	3	4	5	6	7	8	9	10
$Na_3PO_4 \cdot 12H_2O$	32			32	32	55	35	50		9
$Na_4P_2O_7$			4	20			5			
$Na_6P_4O_{13}$					15					
$Na_2SiO_3 \cdot 5H_2O$			40				50	30		29
Na_4SiO_4		85								
Na_2CO_3	46	10		26	31	35		13	60	18
NaOH	16		50	16	16	10	8		30	36
Wetting agent	6	5	6	6	6		2	7	10	8
Concentration in bath (oz. per gal.)	4 to 12	4 to 12				4 to 8	4 to 8	2 to 8	2 to 8	
Temperature	Boil	Boil								

*Based on data from A.E.S. Research Project No. 12.

Requirements of Electrocleaners

little or no tarnishing or attack of nonferrous metals occurs. On the other hand, positively charged metal ions will deposit on the work, which may give loose nonadherent smuts of metals accidentally dissolved in the cleaning solution. Another disadvantage of cathodic cleaning is that hydrogen is evolved at the cathode which tends to diffuse into some metals and cause hydrogen embrittlement, this being especially serious with highly stressed high-carbon steels.

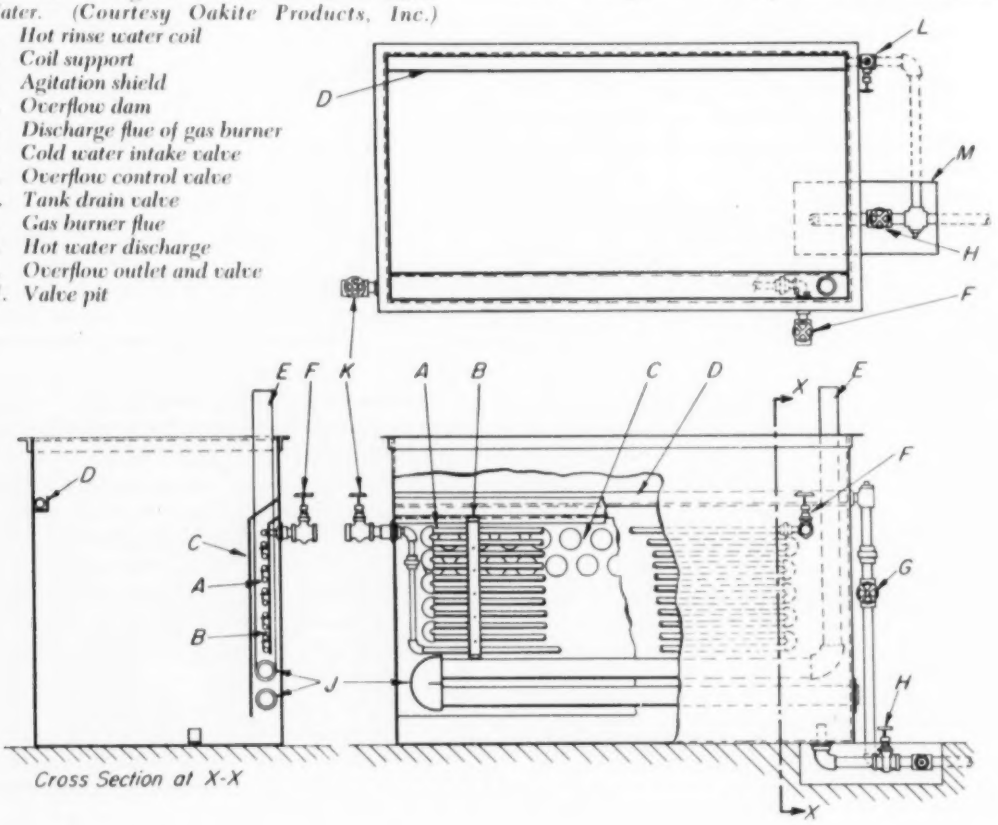
In anodic electrocleaning, commonly known as reverse-current cleaning, there is little tendency for films to deposit on the surface of the parts being cleaned. In fact, there is literally a tendency to "unplate" any films or smuts. At the normal current densities used, up to about 75 amp. per sq.ft., the oxygen generated shows little tendency to oxidize steel or other ferrous alloys. Anodic cleaning does not cause embrittlement of hardened steel.

One essential property of a good electrocleaner is high conductivity. While caustic soda imparts high conductivity to water, it alone is not a very effective detergent. Therefore it is blended with other alkalis which, although possessing lower conductivity, do have more detergent action, better rinsing ability, and a lower pH in solution. For fast, effective action the cleaner should have wetting, penetrating, emulsifying and deflocculating action. To achieve these properties, cleaning solutions generally require the assistance of surface-active agents that will wet and penetrate soils and permit the cleaning solution to destroy the bond between the metal surface and the soil. When soils have been loosened, the cleaning solution should temporarily emulsify oils and greases and suspend solid particles of dirt in a free-rinsing form.

It is important to sequester the calcium and magnesium salts present in tap water so as to prevent a reaction between the soaps in the cleaning solution and the water hardness. Although the cleaner may not be formulated with a soap, the animal and vegetable oils or greases in buffing compounds removed by the cleaning operation are gradually converted into soaps by the action of hot alkalis. The soaps which are generated may form an insoluble,

Fig. 1 – Alkaline Soak-Tank Cleaner Heated by an Immersion-Type Gas Burner, With Water Coil Behind Agitation Shield to Heat Rinse Water. (Courtesy Oakite Products, Inc.)

A. Hot rinse water coil
B. Coil support
C. Agitation shield
D. Overflow dam
E. Discharge flue of gas burner
F. Cold water intake valve
G. Overflow control valve
H. Tank drain valve
J. Gas burner flue
K. Hot water discharge
L. Overflow outlet and valve
M. Valve pit



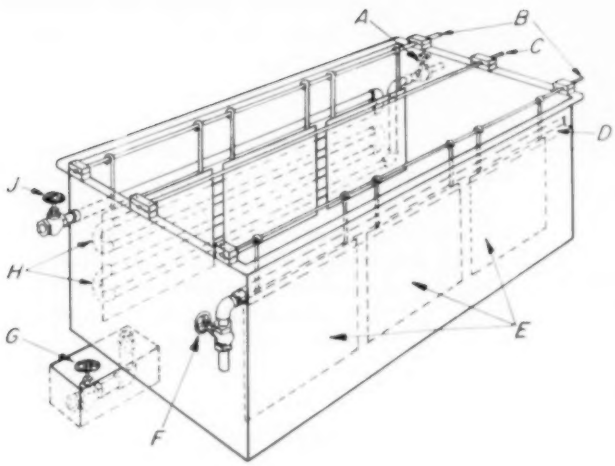


Fig. 2 – Electrolytic Cleaning Tank Equipped With Steam Heating Coils and Overflow Dam. Sheet steel electrodes (E) hang in front of coils and dam and have porcelain insulators at bottom to prevent contact with tank. (Courtesy Oakite Products, Inc.)

A. Steam control valve
B. Anode rods
C. Work rod
D. Overflow dam
E. Steel electrodes
F. Valve in overflow line to sewer
G. Drain valve in small pit
H. Steam coil in back of steel electrodes
J. Steam coil exhaust valve

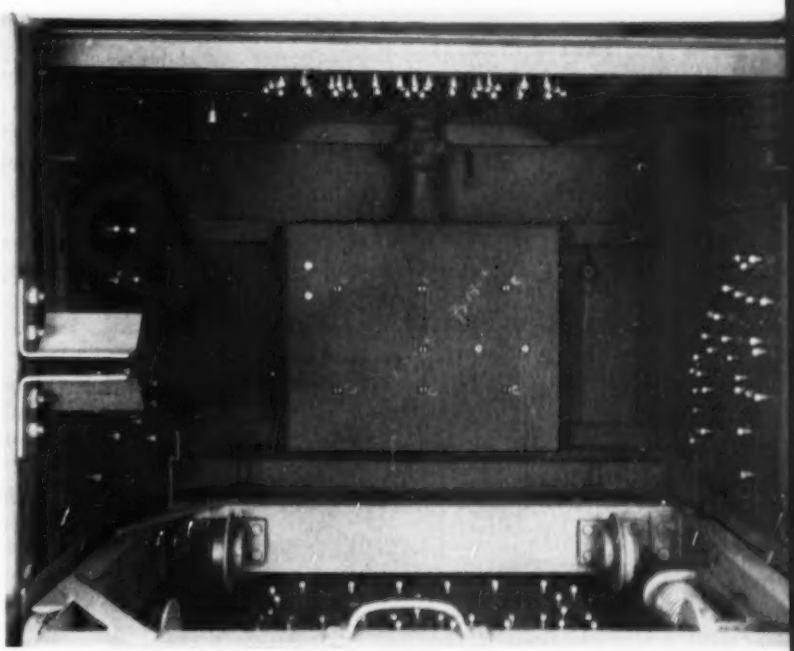
sometimes sticky precipitate with the hardness of the water.

Figure 2 shows one type of tank designed for electrolytic cleaning. The tank is equipped with steam-heating coils and overflow dam, and has sheet steel electrodes hanging from electrode rods in front of coils and dam. Electrodes should have top edges about 3 in. below normal solution level and porcelain insulators at bottom edges to prevent contact with tank sides. Low-resistance contacts, clean anode and cathode bars, and periodic scrubbing of the electrodes all contribute to efficient and economical electrocleaning.

Spray Cleaning – Cleaning in a mechanical washer is made possible by a combination of mechanical and chemical action. In spray washing, the most common method, the force of the spray against the work gives a scrubbing action that aids in removing chips, dirt and other solids. Its "cutting action" speeds emulsification and is effective in areas that in soak cleaning might act as traps for cleaning solution. Figure 3 shows location of high-pressure jets used in an automatic machine for cleaning cast iron cylinder blocks. Concentration of the cleaner for use in a spray washer can usually be lower because of mechanical action; generally from ⅛ to 2 oz. per gal. is sufficient.

Alkaline cleaners intended for spray washing should be nonfoaming to avoid overflow under pumping and spraying action. Other properties needed are free rinsing, water softening, and buffering action. Mechanical washers are well adapted to those applications involving a large volume of work that will justify cost of equipment and operation. Such machines are not only built as washers, but also include rinsing and drying facilities in various combinations. A number of manufacturers offer automatic washing, rinsing and drying equipment in which the parts are conveyed through the processing chambers on a wire-mesh belt.

Fig. 3 – Interior View of Automatic Cleaning Machine Showing Location and Type of High-Pressure Jets Used in Cleaning Cast Iron Cylinder Blocks. (Courtesy R. C. Mahon Co.)



Short Runs

Steelmaking

THREE 20-FT., TOP-CHARGE electric furnaces are replacing three 125-ton openhearths at Timken's Steel & Tube Division at Canton, Ohio, and are expected to produce about 75,000 tons of steel. Most interesting perhaps is that they have "inductive stirrers" attached to their bottom shell – which, by the way, is a nonmagnetic Type 304 stainless steel plate, 1¼ in. thick. Bottom lining is 9 in. of fireclay, 12 in. of magnesite and 10 in. of "Ramset".

The induction stirrer, shown in the adjoining view, consists of a box containing two distilled-water-cooled coils resembling stator coils from a large induction motor. Overheating is prevented by warning signals controlled by no less than 34 positions in coils or on furnace bottom. Up to 390 kva. power at 200 volts is available from motor-generator sets.

The device was developed by Ludwig Dreyfus and proved on 15-ton furnaces at the Uddeholm AB plant, Hagfors, Sweden. It induces currents in the molten steel bath which cause movements generally parallel to the bottom, and directed, at will, either toward the spout or directly opposite toward the slag-off door. Such movements prevent temperature variations or stratification of elements throughout the bath, and accelerate the wash between slag and metal (thus hastening the slag-metal reactions).

Fig. 1 – Pit View, Tapping Side, of 20-Ft. Electric Furnace at Timken's Canton (Ohio) Plant, Showing Inductive Stirrer Under Bottom Plate

Early operations at Timken have been gratifying. Final sulphurs have been reduced 25%; carbon and other elements are held to narrower range. Time for slag making and alloy mixing is reduced. Labor at slag-off is much reduced.

Spot Testing

THE METHOD for the rapid identification of tin, cadmium and zinc of very thin coatings reported by F. Breh, chief chemist, Barnes-Gibson-Raymond Division of Associated Spring Corp., permits testing of these common platings where the spot test alone is complicated by the presence of iron. Spot testing as generally applied gives satisfactory results on medium or heavy platings, but in dealing with very thin coatings, the color of the metal sulphides often is obscured by the presence of iron, which makes it almost impossible to verify the type of plating.

By dissolving the coating with one or two drops of acid, the acid penetrates too fast into the iron and renders the color test questionable or worthless. On the other hand, by not giving enough time to dissolve the plating, too little is in solution to show clearly a desired reaction.

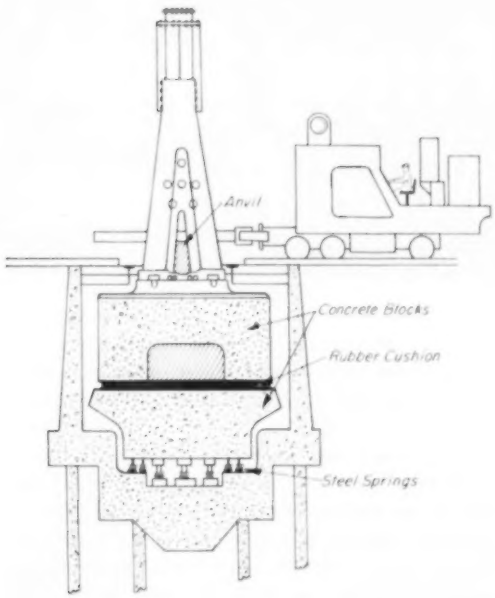
In order to overcome these disadvantages, Mr. Breh suggests the following procedures:

Tin – The well-known cacotheline test is made by dissolving a little of this powder on a strip of filter paper. One drop of concentrated HCl is put on the surface of the material to be tested, and after reaction has taken place, the solution is taken up on the underside of the strip. A violet color shows the presence of tin. Some iron, dissolved by the hydrochloric acid, will not interfere.

Cadmium – Sample is placed into a 10% ammonium nitrate solution at room temperature until some or all of the coating comes off. A few milliliters of the solution is poured in a test tube and to this a small amount of sodium sulphide solution is added. A bright yellow color or precipitate confirms the presence of cadmium. Traces of iron which may be present do not interfere.

Zinc – Should the test for cadmium show a precipitate, it is likely to be zinc sulphide. Verification of this is made by adding a few drops of concentrated H_2SO_4 slowly into the test tube. This is boiled for a few seconds and then filtered to remove the free sulphur. To the clear filtrate a few milliliters of potassium ferrocyanide solution is added; a white precipitate confirms the presence of zinc. Occasionally some colloidal sulphur may pass through the filter paper. This condition can be corrected by heating the solution a little longer.

Forging



DAMAGE to buildings and equipment caused by vibrations from the impacts of large forging hammers invariably is costly and continuous unless their intensity is diminished. Such a condition existed at International Nickel Co.'s plant in Huntington, W. Va., where ingots of nickel alloys are forged down for subsequent processing into sheets, rods and such. To reduce vibration, the old solid foundation of concrete and timbers was torn out and replaced by a more resilient base.

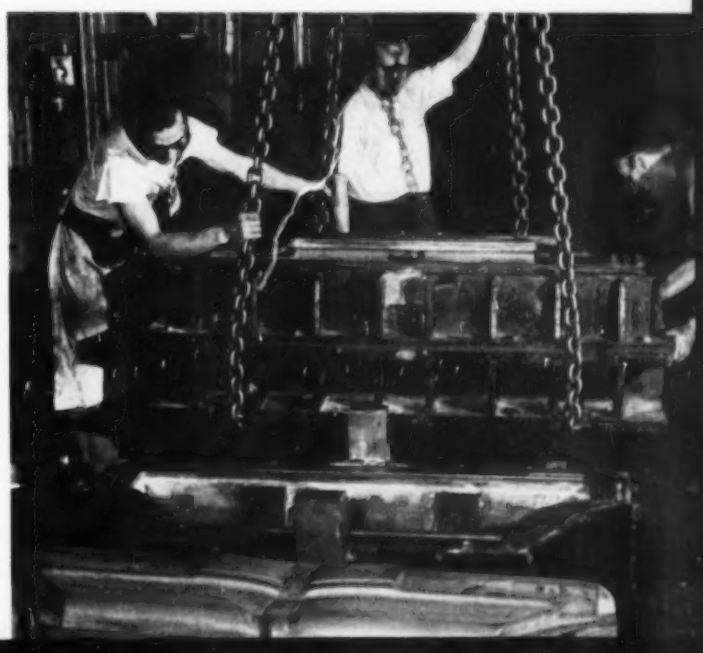
The new system of mounting the 16,000-lb. forge consists of two blocks of concrete isolated from the rest of the foundation pit; they function as semi-free bodies for the absorption of the impact. As shown above, the legs and anvil of the hammer are bolted to the upper block of concrete (about 21 ft. long, 18 ft. wide and 10 ft. thick). Top and bottom blocks are separated by a rubber cushion sandwiched between steel plates, and the lower block rides on more than 400 coil springs. The foundation, from the top block to bottom of the piles, reaches 40 ft. below the floor line.

Stamping

RESULTS OF A PRODUCTION TEST, using a punch and die made of thermosetting phenolic material for forming automobile panels, show that "plastic" may prove to be an acceptable substitute for steel in this application. The material has already been used extensively by the aircraft industry for short runs on aluminum and stainless steel sheet. Several hundred steel cowl panels were made in this test run for the Dodge Truck Division at Chrysler Corp.'s stamping plant at Detroit.

A potential advantage in using this kind of die is its lower cost. The conventional stamp and die require about 6000 lb. of steel as compared with the 1500 lb. of plastic material, and 14 to 16 weeks of production time for the former as contrasted with less than three weeks for the latter. Also, little or no machining is needed to finish the component parts of the die after they are cast (see view below).

The cast die is made by pouring the liquid plastic into a plaster mold representing the finished shape desired. This first casting is then used to form the other half of the die, after a coating of wax is applied to simulate the thickness of the finished steel part. Finally, the bottoms and edges are encased with heavy steel plate to prevent them from spreading out of shape during their use.



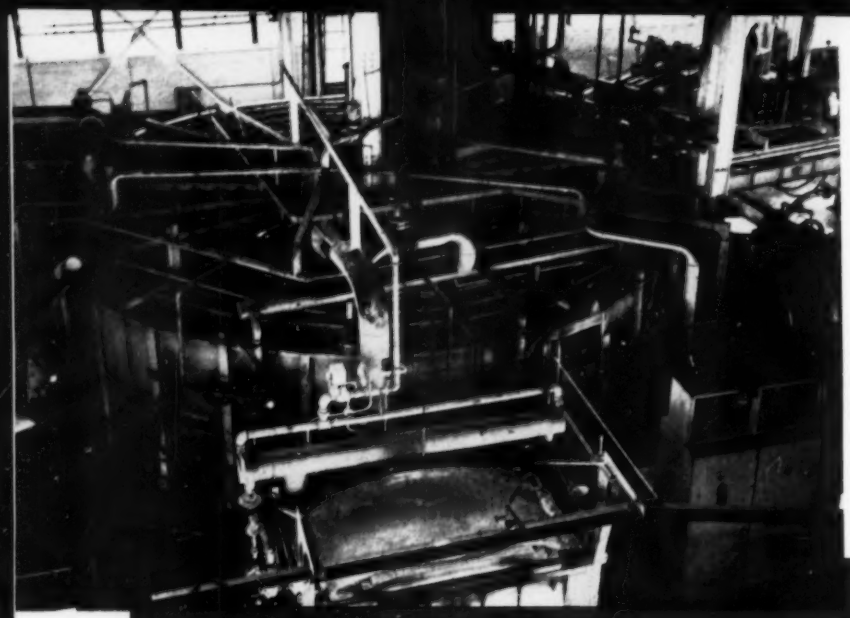


Fig. 1 – Overhead View of Rotary-Hearth Doughnut-Type Furnace for Heating Billets Prior to Press Forging. Oil-fired, the 32-ft. diameter unit will handle up to 300 billets per hr.

Continuous Press Forging System Uses Novel Furnaces

INTEGRATION of heating and heat treating equipment into a mechanized production line is a technique which high volume of output and intense pressures on costs have made practical – in fact, almost imperative in automobile manufacture, despite the enormously heavy investment required. One of the most up-to-date examples is at the new press forging shop at Chrysler Corp.'s Dodge Division forge plant in Detroit, now turning out crankshafts of both V-8 and 6-cylinder design at a production rate three times greater than by the old method.

Among the unusual elements in the system is a rotary-hearth, doughnut-type billet heating furnace 32 ft. in diameter, mechanically loaded and unloaded, which can supply as many as 300 heated billets an hour to the adjoining forging press. Normally it is operated at about half this speed, carrying two rows of 106 to 125-lb. square billets around its annular hearth in about 60 min. to bring them to forging heat of 2250 to 2300° F. Burners, started on gas and fired by oil during the operating cycle, are positioned on both sides of the moving hearth.

By ARTHUR H. ALLEN
Technical-Business Consultant, Cleveland

Loading and unloading of the 4½-in. square billets of S.A.E. 1045 is accomplished automatically and mechanically, as are virtually all other operations in the forging sequence. The billets are brought from the storage yard by a magnet crane to a rack in the plant wall, and pushed by a hydraulic cylinder into a warming oven where they are heated to 400° F. to avoid the development of cracks during shearing. From the billet shear, the cut pieces move down a conveyer to an elevator which raises them one at a time to a hydraulically operated device for charging into the furnace.

This unit, equipped with fingers which clamp the billet at its ends, raises it from the elevator platform, carries it above the hearth and lowers it gently to avoid wear and possible damage to the refractory which would result if the steel were slid into position. Each loading cycle is followed by movement of the hearth sufficient to make room for the succeeding billet. Hearth travel is electrically synchronized with the loading mechanism. At the unloading station, which is adjacent to the loader, a similar handling unit operating in reverse picks up the hot billet, retracts it from the furnace and places it on a gravity roller conveyer which carries the billet

to a four-jet water descaler operating between 1500 and 2000 lb. pressure.

To some forging specialists the use of a fuel-fired heating furnace and descaler in preference to heating by electric induction direct to the press may seem behind the times. However, factors other than modernity must be considered. On this score the energetic manager of this forge plant, an experienced hammerman himself, points out that careful study was made of all types of heating, including induction, and the decision to install an oil-fired rotary furnace was made primarily on the basis of initial and operating costs.

For one thing, the entire present installation (representing an outlay approaching $3 million) is just one "line" in this plant of 70,000 sq.ft. which may eventually become the center of all production of crankshafts, ring gears, connecting rods, rod caps, gears and torque converter components for the four Chrysler divisions. A second line, including all basic units of the first, is now being installed and should be operating by next April. Equipment for a third is on order. Induction heating equipment for all three might have pushed costs out of line, giving particular consideration to the fact that the present line is permitting cost savings of at least 25% over previous methods.

A completely new building 150 x 460 ft. in dimensions, of high-bay design with good lighting and ventilation, was erected so there would be ample space around equipment, making for ideal working conditions. Automatic features of equipment operation and material handling eliminate the need for operators having specialized forging skill or doing heavy work. Full advantage has been taken of the engineering knowledge made available by equipment suppliers, and this, implemented with the added knowledge possessed by automotive industry specialists in using integrated transfer-type machinery, has resulted in a showplace of advanced forging techniques which should more than meet the demands and limitations of today's costs and labor market.

To return to the detailing of operations, before the heated billet reaches the forging press, it passes through a preforming treatment, known as a reducer roll or die-rolling machine, which "gathers" the steel for proper distribution

Sequence of Operations

in crank throws and lessens the force required by the press to shape the shaft.

As the preformed billets emerge from the reducing roll stand, they intercept a photocell beam and this actuates an air-driven piston which flips them end-over-end and positions them properly for entry to the forging press. A conveyer completes the transfer. The press is a 6000-ton high-speed mechanical forging unit, driven by a 400-hp. motor and capable of delivering up to 35 strokes a minute. It is provided with two dies, side by side, with the forging being given one strike in each to form the shaft completely, except for trimming and flanging. After the second strike, an operator pushes the forged shaft onto a conveyer which delivers it to a trim press. An operator, with the aid of tongs, locates the part squarely in the trim die and pulls off the trimmed flash to a chute which deposits it on a conveyer below floor level for removal to scrap bins.

With the assistance of an overhead trolley and tongs, another operator places the shaft in a 4-in. upsetter for flange forging to save subsequent machining. Shafts for V-8 engines are forged flat and are moved on a roller conveyer to a hydraulically operated twisting machine which brings the crankpin bearings into exact

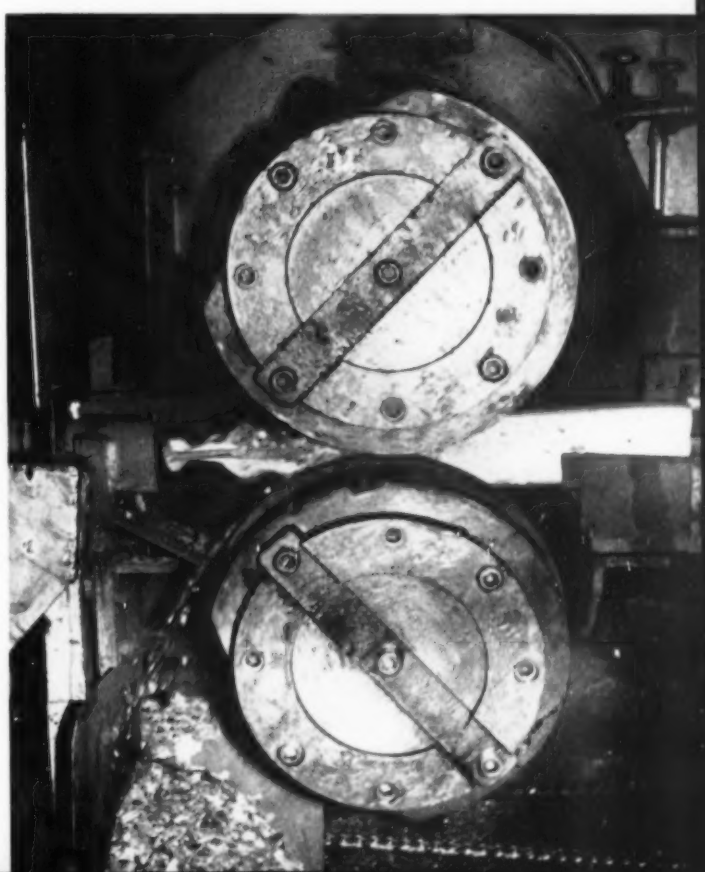


Fig. 2 — Reducer Rolls Preform the Hot Billet Before It Enters the Forging Press. Steel is reworked so that heaviest sections will be in approximate location of heaviest portions of the shaft

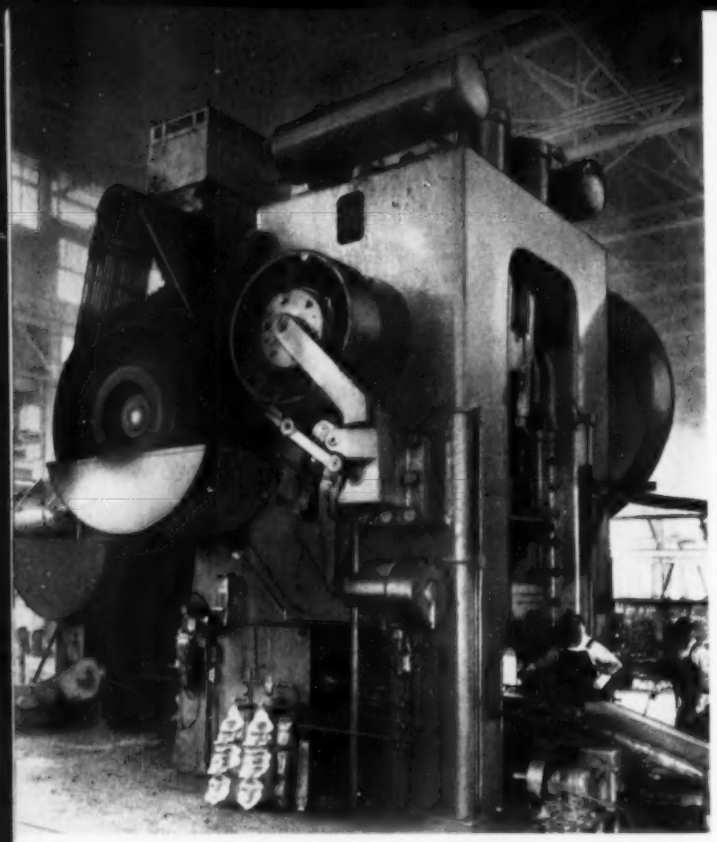


Fig. 3 — This 6000-Ton Mechanical Forging Press, Driven by a 400-Hp. Motor, Is Claimed to Be the Largest Ever Built for This Type of Work. Forged shafts may be seen in the lower foreground

alignment or index. Six-cylinder shafts are press forged in correct alignment and need no subsequent twisting. As a final check, however, both types of shafts are given a final restrike in a press before being transferred to an overhead monorail conveyer for heat treatment.

Following passage through an air cooling zone on the overhead conveyer, forgings arrive at the start of the heat treating sequence, where they are transferred by air hoist to alloy steel carrier fixtures. Carriers accommodate four shafts each and move in pairs through the hardening furnace, quench, tempering furnace, final water cooling and shot-blasting, all the while on the monorail conveyer. Travel is of intermittent nature, in cycles of just over 3 min. By suspending the shafts vertically from overhead carriers, a variety of sizes and shapes of parts can be heat treated. Also there is a minimum amount of metal in fixtures, reducing the load on the furnaces.

The gas-fired hardening furnace for operation at 1550° F. is of somewhat unusual design in that it is built around a central "corridor" through which the suspended shafts travel. Heating requires approximately 100 min. Immediately after emerging from the furnace, the shafts and their carriers are lowered into a water quench which is held at 90° F. and continuously agitated. After 70 sec. in the quench they are elevated and returned to the monorail conveyer over which they pass to a gas-fired tempering furnace. Entry again is intermittent, and is on the same 3-min. cycle. Tempering is done at 1125° F. and requires 2 hr. At the exit from this furnace another elevator mechanism lowers the shafts briefly into a tank of cooling water, and raises them for return to an overhead conveyer leading to a shot-blast cabinet.

This ends the trip on the overhead line. With the aid of an air hoist, operators transfer the shafts to a roller conveyer and the carriers are routed back to a storage bank or to the supply station which feeds the charging end of the hardening furnace.

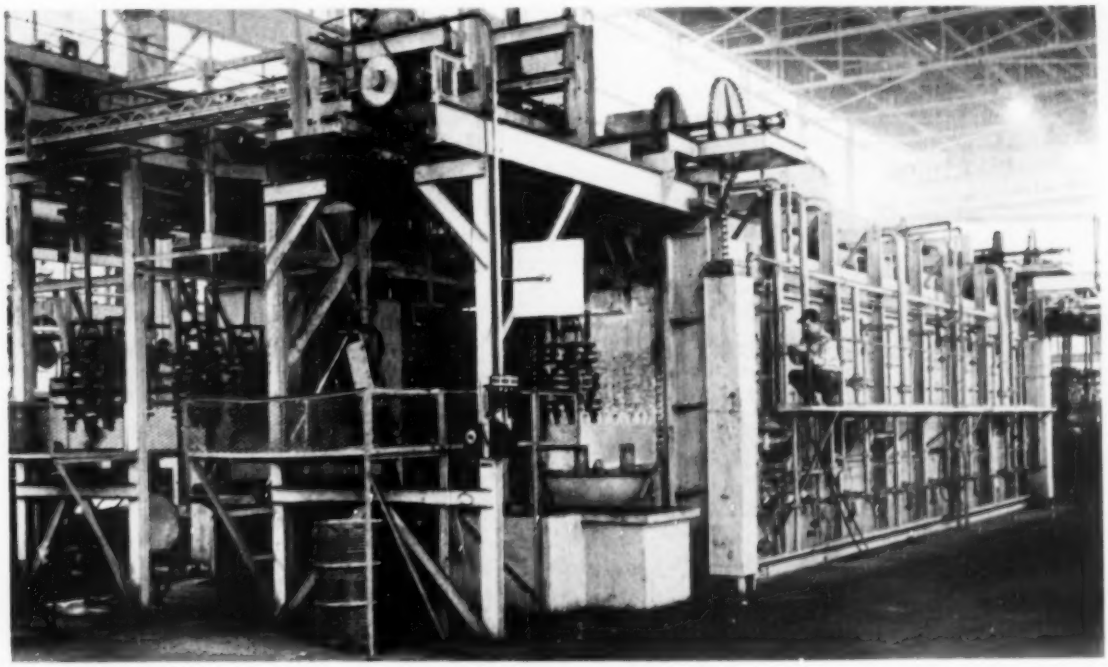
Before final inspection, the shafts are center-drilled for subsequent locating in machining operations. Centering is set up and performed to constant dynamic balance checks, while a following alignment procedure straightens the forging to static balance on live centers. Inspection includes gaging major dimensions and checking for hardness and visual defects. Hardness is in the range of Brinell 415 to 500.

Fig. 4 — Two-Position Die Is Used, as Shown in This Close-Up, and Only One Strike Is Required in Each Cavity. Press can deliver more than 35 strokes per min.

Probably the most striking feature of the entire sequence is the ingenious synchronization of the material handling operations. It involves an elaborate system of electrical, mechanical and hydraulic devices, some of them relatively new in the metalworking industry. Plant officials point out that nearly 11 miles of electrical wiring alone was required to tie in the various equipment and devices for handling materials, as well as for the controls of the heating furnace, main and supplementary presses, heat treating furnaces and the numerous blowers. Together with the electronic controls required to actuate mechanisms, this variety of equipment makes a complex and costly system and one that requires close vigilance from the maintenance crews. High production demands, high labor rates, and exacting quality control are pushing industry to rapidly widening use of automatic production methods. This trend is observable not only in the forge shop but throughout the automotive industry.

Fig. 5 – Shafts for V-8 Engines Are Forged Flat and Then Twisted to Proper Alignment in This Press. Six-cylinder shafts do not require twisting

Fig. 6 – Unusual Design Is Reflected in Twin Automatic Gas-Fired Hardening and Tempering Furnaces. Shafts are suspended from carriers, each holding four shafts, which travel on overhead monorail and move through the furnaces intermittently at 3-min. intervals. Run through this furnace takes about 100 min.



Critical Points

by the Editor

The Army's Big Gun

Just prior to ASM's National Metal Exposition in Philadelphia last fall, the Editor attended a demonstration of the U. S. Army's 280-mm. cannon (dubbed "atomic gun" in the popular press) at Aberdeen Proving Ground, along with a regiment of officers and civilians of the well-fed, executive type, to say nothing of a squad of photographers, each, apparently, with his own unstandardized type of equipment. To the Army, its prime significance is an "all-purpose gun capable of firing an atomic projectile with precision accuracy in all kinds of weather" – in the words of Frank Pace, Jr., Secretary of the Army. To a civilian engineer its prime significance was in its design and construction; conventional ideas were abandoned wholesale and the result is a powerful, heavy unit, mobile, rapid and adaptable. Gen. J. Lawton Collins, Army Chief of Staff, admitted that its range (about 20 miles) is still less than desirable, although he predicted that guided missiles would soon serve as truly long-range projectiles. Its accuracy, said to be ¼ of 1% (in technical parlance meaning that half the shots land within a line of fire of ¼ × 1% × 20 miles, or 265 ft.), is hardly "pinpoint" accuracy even though unusually high, but it is doubtless ample for an atomic explosive whose radius of destruction may be measured by miles.

This is hardly the place for a detailed description of the gun; it is shown on the road in the photograph opposite (minus its convoy of four 5-ton trucks carrying crew, ammunition, projectile carts, and 30-kw. power plant). Gun and its mount form a self-contained unit carried by two transporters, front and rear. The piece weighs about 50 tons and the transporters about 17 tons each, yet the entire 85 tons produce wheel loads on about the same order as other mobile equipment of an Army division. Transporters move on roads at 35 miles per hr., and can be swung into any flat field, gun emplaced, barrel slid back into its cradle tube, loaded, and fired in 20 min. Its getaway is equally speedy.

As can be seen in Fig. 1, stout forked yokes reminiscent of heavy equipment for lumbering are locked to the ends of the girder-like gun carriage, the whole forming a rigid beam that bears on end pintles on the free-wheeling transporters, front and rear. Arriving at the site, the load is taken by vertical hydraulic jacks permanently mounted on transporters, locking keys between yokes and gun carriage knocked out, and the lattter lowered away – whereupon transporters and their yokes depart. The gun and carriage are balanced so nicely on a round turntable under the center of gravity that a couple of men can swing it to the proper direction, and a rear support or "float" (shown under the carriage just behind the forward transporter in the photograph) is jacked down. This rear "float" has a radial rack with pinion, and is used to aim the gun a few degrees to right or left. While all movements except transverse are power-driven, duplicate hand controls are installed for emergencies.

Such a simple bearing on the earth – merely the central turntable and the rear "float" – would indeed seem flimsy in comparison with the heavy trails and spades on conventional field pieces of much smaller caliber, but this gun has a unique double recoil system. Unfortunately this is not shown in the view, since the recoil cylinders are under the trunnion and within the carriage. One recoil system is quite similar in function to the conventional devices used on howitzers, permitting the gun tube to kick backward in its cradle tube at the moment of firing. The second recoil system permits the entire carriage to slide backward one quarter its length on the central turntable and rear "float". Thus nearly all of the energy is absorbed by the inertia of these heavy components, and little force goes through to the ground. Much dust is kicked up at the gun site, but it is caused by the vicious muzzle blast rather than the recoil.

Portability requires lightweight design and construction – and this includes transporters as well. Many of the metallurgical details will be kept under wraps until one of these guns is captured by the enemy, but from Fig. 2, showing shop assembly, it can be seen that the carriage is similar to a plate girder bridge, 38½ ft. long. Each girder is double-webbed, and is welded of thin plates of 50,000-psi. yield steel. Bottom flanges are of stainless steel, machined as a slide to fit into ways on turntable and rear carriage support (this "float" is shown with

"The future shall belong to the free"—Dwight D. Eisenhower

its aluminum tie rods in the lower right corner). To insure sound welded joints, nearly all welding was done down-hand; units were stress-relieved and all joints inspected by magnetic powders or dye penetrants. Cradle tube assembly, which is supported on the carriage with trunnions, includes a large alloy steel casting with stiffeners and auxiliaries of the same analysis welded on while preheated at 700° F. One of the prime requirements was to use the very minimum of strategic alloys. Hence the usual 4340 (Ni-Cr-Mo) steel was used sparingly, being replaced by 1040 forgings of thin enough section to be through-hardened in heat treatment. The gun tube itself is of jacketed construction rather than strengthened by autofrettage; tube, jacket and recoil cylinders were forgings of a special alloy steel, that was heat treated to 125,000-psi. yield – far better than the 70,000-psi. specification which obtained during World War II. As a matter of fact, it was discovered that the double-recoil design saves much weight in comparison with the conventional single-recoil mechanism, so that *design* rather than high-strength metal is responsible for the major economy in poundage. Only minor use was made of the light metals (as in ammunition slide or gear covers), except that aluminum tie rods hold the rear "float" to the central turntable.

Research at the Franklin Institute

At the unveiling ceremony credit was given to a group of engineers and scientists of the Franklin Institute of Philadelphia for the engineering studies and general design and layout of the big gun and its carriage. This surprised the Editor, who had the impression that the venerable Institute's functions were chiefly historical and educational. Maybe readers of *Metal Progress* are under the same misapprehension. The facts are these:

Early in the 1940's it became evident that the war in Europe was a very mobile affair and existing American equipment (inherited from the static operations of World War I) would be quite inadequate. Competent officers were badly needed elsewhere, so Maj. Gen. G. M. Barnes, then chief of research and development of the Ordnance Dept., asked Rupen Ecksergian, then with the Budd Co. and a recognized authority on ordnance and ballistics, to organize a group of designers. Quarters were offered by Franklin Institute, and Frank S. Chaplin of Budd's engineering department, A. J. Olander of Westinghouse's steam turbine

Fig. 1 – The Army's New 280-Mm. Gun and Mount Ready to Take the Road. Stout forked yokes, keyed to the gun carriage, transfer the load to main bearings on the transporters, front and rear. Gun tube is retracted from its cradle tube with breech block at forward end (over transporter at left). Note the circular turntable below center of girder-like gun carriage, and the rear carriage support just behind the wheels of the leading transporter. (U. S. Army Photograph)

Fig. 2 – Assembly of Carriage and Gun Tube at Dravo Corp., Pittsburgh. Extensive use of welded, high-yield, low-alloy steels, and improved analyses for gun and recoil cylinders, reduced weight to a minimum. Rear support and aluminum tie rods are shown at lower right

department, A. L. Bergholm, a bridge engineer and stress analyst formerly with the New York Port Authority, and George S. Hoell, the associate director of the Franklin Institute, joined early in 1943.

This nucleus was responsible for the early studies of a new tank gun and a tank-mounted howitzer which was getting into production at the end of the war. It also designed several 105-mm. weapons, as well as the present 280-mm. gun when it was found that a projectile containing an atomic war head was practicable.

Two other scientific and engineering groups were also very active at the Institute during the war. One intensively studied the erosion of gun tubes, and the other (an electronics group) devised some superior sub-hunting and airborne fire-control equipment.

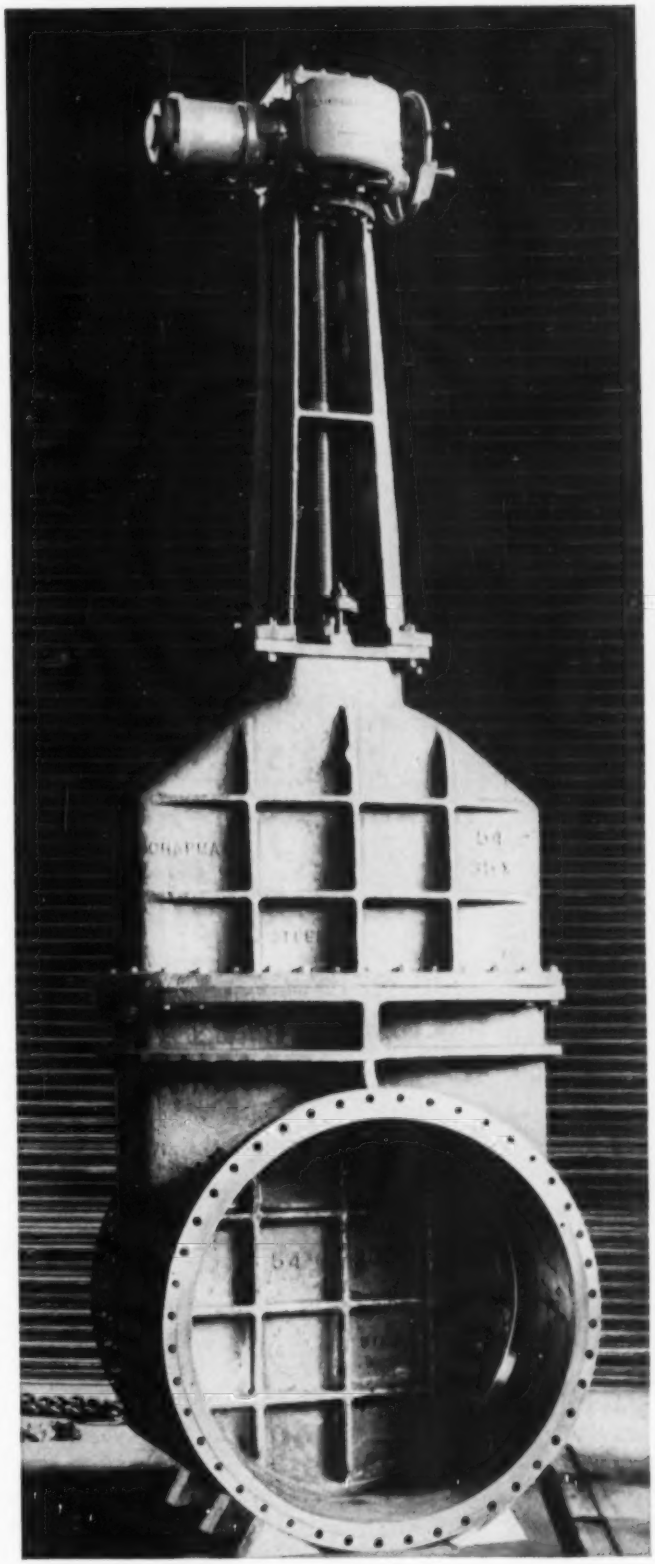
Meanwhile space overflowed into temporary buildings and neighboring residences. At present the Franklin Institute is building new quarters to house its laboratories for research and development. These laboratories started from the above work and at present are subdivided into four main divisions: chemistry and physics, electrical engineering, mechanical engineering, and solid-state physics and metallurgy. Dr. Nicol H. Smith is director of the entire effort.

The gun design group has been retained and is busy on several items of ordnance (Army personnel having been sharply depleted by retirements or return to civilian status). In the mechanical engineering department interesting studies are under way on compact power packages for industry – hydraulic turbine-pump combinations of unusually light weight per horsepower.

Current projects in the research laboratories of interest to metals engineers are on magnets made of pure, very finely powdered iron, and on semiconductors like germanium and silicon. Important work is under way on bearings; studies of friction of metal to metal at *very* high speed without lubricant, or with unconventional lubricants and under stop-and-start cycles, require elaborate measuring and transmitting equipment (mostly electronic) to record continuously the observations made within tightly closed chambers. Another project sponsored by the Association of American Railroads is on railroad journal bearings – a difficult one because a good car bearing, properly maintained, doesn't wear; only when some dirt gets in is there trouble.

Chapman Casts World's Largest Stainless Gate Valve

9-ton casting produced in austenitic chromium-nickel stainless steel



This valve, produced by The Chapman Valve Manufacturing Co., Indian Orchard, Mass., for the defense effort, is used in corrosive water service. It is stated to be the world's largest, with an overall height of 19 feet, weighing approximately 18,000 pounds. The rough casting weight was approximately 36,000 pounds.

Cast in low carbon 18-8 chromium-nickel stainless steel, it is one more demonstration that size is no limiting factor when you cast parts in stainless steels to provide resistance to corrosion and erosion.

Stainless steel resists attack by nearly all oxidizing acid conditions. In addition, it helps you trim bulk and deadweight without sacrificing strength and safety.

At elevated temperatures, austenitic chromium-nickel stainless steels are distinguished by their strength and outstanding resistance to oxidation. At temperatures down to −320° F. they retain their toughness and unusual strength.

Investigate all the benefits stainless steels can give you. Leading stainless steel companies and foundries produce nickel-containing stainless steels in all commercial forms. A list of sources of supply will be furnished on request.

At the present time, the bulk of the nickel produced is being diverted to defense. Through application to the appropriate authorities, nickel is obtainable for the production of austenitic stainless steels for many end uses in defense and defense supporting industries.

INCO

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N.Y.

Standard Commercial Wrought Tin and Aluminum Brasses, Bronzes and Nickel Silvers

Compiled by Arthur H. Allen from data published by the Copper & Brass Research Assoc. (Revised to August 15, 1952)

Names (Current and Obsolete)	Nominal Composition, %	Forms Most Commonly Ordered, Indicated by (*) or by Reference to Nearest Applicable A.S.T.M. Specification					Range of Mechanical Properties, Hard and Soft, All Forms				Fabrication Processes	Fabricating Properties
		Rolled Plats	Drawn Rods and Plats	Shapes	Wire (Except Flat)	Tube	Tensile†	Yield†	Elong. in 2 In.	Shear†		
Tin and Aluminum Brasses												
Inhibited admiralty Obs: Admiralty alloy Admiralty metal	Cu 71 Sn 1 Zn 28	B171	—	—	*	B111	55—48	22—18	65—60	—	Forming and bending, machining	Excellent cold, fair hot working; machinability 30; excellent soldering; good brazing; welding fair, best by oxy-acetylene
Naval brass	Cu 60 Sn 0.75 Zn 39.25	B21, Alloy A B124, No. 3 B171	B21, Alloy A B124, No. 3	B21, Alloy A B124, No. 3	*	*	88—55	66—25	50—17	45—40	Blanking, drawing, forming and bending heading and upsetting, hot forging and pressing, hot heading and upsetting, shearing	Fair cold, excellent hot working; machinability rating 30; excellent soldering; good brazing and oxy-acetylene welding; fair carbon arc and resistance welding
Leaded naval brass	Cu 60 Sn 0.75 Pb 1.75 Zn 37.5	—	B21, Alloy C	B21, Alloy C	—	—	75—57	53—25	40—15	40—36	Hot forging and pressing, machining	Poor cold, good hot working; machinability rating 70; excellent soldering; good silver brazing; fair to poor welding
Manganese bronze (A)	Cu 58.5 Sn 1.0 Fe 1.0 Mn 0.3 Zn 39.2	*	B124, No. 4 B138, Alloy A	B124, No. 4 B138, Alloy A	*	—	84—65	60—30	33—19	48—42	Hot forging and pressing, hot heading and upsetting	Poor cold, excellent hot working; machinability rating 30; excellent soldering; good brazing and welding
Aluminum brass	Cu 76 Al 2 Zn 22	—	—	—	—	B111	60	27	55	—	Forming and bending	Excellent cold, fair hot working; machinability 30; good soldering, brazing, welding
Phosphor Bronzes (Tin Bronzes)												
Phosphor bronze 5% (A) Obs: Phosphor bronze —Grade A	Cu 95 Sn 5	B103, Alloy A	B139, Alloy A	—	B159, Alloy A	*	140—47	80—19	64—2	—	Blanking, drawing, forming and bending, heading and upsetting, roll threading and knurling, shearing, stamping	Excellent cold, poor hot working; machinability 20; excellent soldering; good brazing and welding
Phosphor bronze 8% (C) Obs: Phosphor bronze —Grade C	Cu 92 Sn 8	B103, Alloy C	B139, Alloy C	—	B159, Alloy C	—	140—55	80—24	70—2	—	Blanking, drawing, forming and bending, shearing, stamping	Good cold, poor hot working; machinability 20; excellent soldering and resistance welding; good gas and carbon arc welding
Phosphor bronze 10% (D) Obs: Phosphor bronze —Grade D	Cu 90 Sn 10	B103, Alloy D	B139, Alloy D	—	B159, Alloy D	—	147—66	28‡	70—3	—	Blanking, forming and bending, shearing	Good cold, poor hot working; machinability 20; excellent soldering and resistance welding; good brazing, gas and arc welding
Phosphor bronze 1.25% (E)	Cu 98.75 Sn 1.25	*	—	—	—	—	79—40	50—14	48—4	—	Blanking, forming and bending, heading and upsetting, shearing, squeezing and swaging	Excellent cold, good hot working; machinability 20; excellent soldering and brazing; good welding except fair resistance welds
Cupronickel and Nickel Silvers												
Cupronickel 30% Obs: 70-30 cupronickel	Cu 70 Ni 30	B122, No. 5 B171	*	—	—	B111	75—54	70—20	45—15	—	Forming and bending	Good working qualities; machinability 20; excellent soldering, brazing and resistance welding; good gas, fair arc welding
Nickel silver 65-18 Obs: Nickel silver —Alloy A	Cu 65 Ni 18 Zn 17	B122, No. 2	B151, Alloy A B206, Alloy A	—	B151, Alloy A B206, Alloy A	—	103—56	90—25	40—3	—	Blanking, forming and bending, drawing, etching, heading and upsetting, roll threading and knurling, shearing, spinning, squeezing and swaging	Excellent cold, poor hot working; machinability 20; excellent soldering, brazing, and resistance welding; good gas welding; fair arc welding
Nickel silver 55-18 Obs: Nickel silver —Alloy B	Cu 55 Ni 18 Zn 27	B122, No. 4	B151, Alloy B B206, Alloy B	—	B151, Alloy B B206, Alloy B	—	145—60	90—25	40—2	—	Blanking, forming and bending, shearing	Good cold, poor hot working; machinability 30; excellent soldering, brazing, resistance welding; good gas, poor arc welding
Nickel silver 65-15 Obs: 15% nickel silver	Cu 65 Ni 15 Zn 20	*	—	—	—	—	92—53	79—18	43—2	54—41	Blanking, drawing, etching, forming and bending, heading and upsetting, roll threading and knurling, shearing, spinning, squeezing and swaging	Excellent cold, poor hot working; machinability 20; excellent soldering, brazing, resistance welding; good gas and fair carbon arc welding
Nickel silver 65-12 Obs: 12% nickel silver	Cu 65 Ni 12 Zn 23	*	—	—	*	—	93—52	79—18	48—2	56—41	Same as for nickel silver 65-15	Same as for nickel silver 65-15
Nickel silver 65-10 Obs: 10% nickel silver	Cu 65 Ni 10 Zn 25	*	—	—	*	—	130—49	76—18	50—1	59—41¶	Same as for nickel silver 65-15	Same as for nickel silver 65-15
Silicon Bronzes (Copper-Silicon Alloys)												
High-silicon bronze (A) Obs: Silicon bronze —Type A	Cu 96 Si 3	B96, Alloy A B97, Alloy A B98, Alloy A B100, No. 2	B98, Alloy A B124, No. 7 B98, Alloy B	B98, Alloy A	B99, Alloy A	*	145—56	70—21	70—3	70—42	Blanking, drawing, forming and bending, heading and upsetting, hot forging and pressing, roll threading and knurling, shearing, squeezing and swaging	Excellent in all working qualities; machinability 30; excellent for all joining methods
Low-silicon bronze (B) Obs: Silicon bronze —Type B	Cu 97.7 Si 1.5	B97, Alloy B B98, Alloy B	B124, No. 8	B98, Alloy B	B99, Alloy B	*	95—40	69—15	55—11	53—36	Forming and bending, heading and upsetting, hot forging and pressing, roll threading and knurling, squeezing and swaging	Excellent in all working qualities; machinability 30; excellent for all joining methods

Notes

Alloys herein listed are standard in the sense that over a period of years they have been the ones most commonly used in larger quantities. In addition to them, there are many special and proprietary alloys which are produced by mills for various uses, including such materials as aluminum bronzes, cadmium bronzes, beryllium coppers, aluminum-tin bronzes, aluminum-silicon bronzes, silicon bronzes, copper-chromium alloys and other combinations for special applications.

*Forms commonly ordered.

†Tensile strength, yield strength at 0.5% strain, and shear strength are given in units of 1000 psi., and the range is from hardest to softest commercial forms attained by cold work, heat treatment, or both.

‡For 66,000-psi. tensile strength.

¶Range for flat products.

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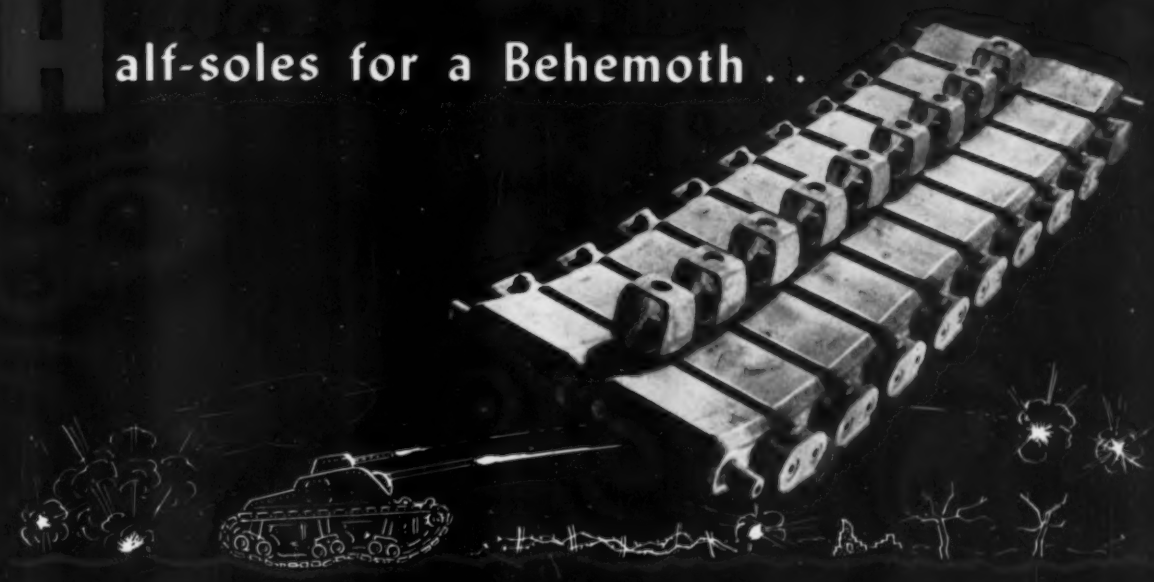

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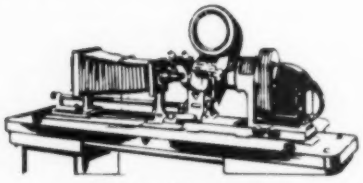

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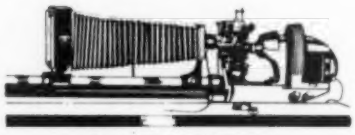

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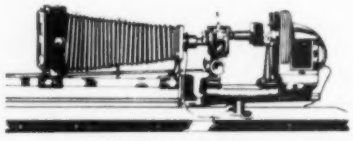

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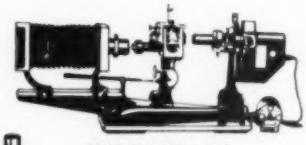

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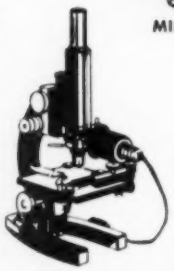

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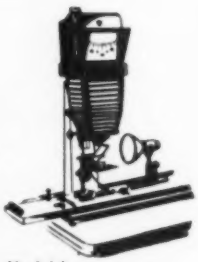

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Tire Molds . . an Advanced Example of the Casting Art

In the year 1934 the management of Goodyear Tire & Rubber Co. of Akron, Ohio, decided that some special attention should be paid to the more economical and rapid manufacture of tire molds. At that time the method used throughout the rubber industry was to bore out a bowl-shaped steel casting (the mold is split into upper and lower halves along its center circumference) and then engrave the tread corrugations, in reverse, on its inside rim. Tread designs were rather simple, but even so the costs and delays were mounting continually. Engraving methods simply did not fit into the current and anticipated developments in tire design and construction.

Maybe the thing to do right now is to stop and try to explain how pneumatic tires are made and why such a thing as a tire mold is necessary.* (In what follows the word "tire" will mean the outer tube or casing, be it for bicycle, touring car, truck, airplane landing gear, farm tractor, or huge earth-mover; Goodyear at present manufactures over 2500 types and sizes, varying as to dimension, working pressure or tread design.)

The body of these tires, midway in fabrication, is a squat, black, open-ended barrel of quite pliable material, and the interesting fabricating methods up to this point could be described if space permitted; constitution of the tire may be visualized from Fig. 1, a section cut across a so-called "four-ply" tire, such as is used in an ordinary automobile.

The material for each ply is, in effect, a blanket of uncured rubber from 0.030 to 0.045 in. thick – in which are embedded parallel cords of rayon, cotton or nylon, spaced from 26 to 35 to the inch, and stretching across at an angle to the axis. (Alternate plies criss-cross at this chosen angle.) Ply after ply is assembled on a revolving drum; they adhere to each other, since the rubber is quite tacky. An overlapping portion or skirt at each edge is turned inward against the end of the drum – carefully, to avoid wrinkles – and against this is placed a ring of rubber in which is embedded the wire to reinforce the bead which clinches the tire onto the steel wheel-rim. Then the surplus skirt is folded back, outward and upward to enclose this bead. Lastly, a somewhat narrower but thick blanket of rubber to form the tread is wrapped around the outside; this has no cord or other reinforcement, and has chamfered ends for a lap joint which is fused during the later curing operation.

This barrel-shaped, somewhat limp object must next be expanded in its center and shortened in its length, so it assumes the toroidal shape of a tire – a horseshoe in cross section. This is done with the help of a "steam bag" which looks like a husky inner tube. It is in effect just that, although it has walls from ½ to ¾ in. thick (depending on size of tire). Thus, it is a thick-walled doughnut which is forced into the barrel-shaped carcass; when it is inflated it draws the two ends of the carcass closer together and expands the center portion until the correct horseshoe shape is assumed.

Shaped tire and air bag are then laid flat in the lower half of a tire mold, the steam bag is connected to a steam line, and the upper half of the mold clamped down. The outer surface of the shaped tire body obviously must slightly (but only slightly) clear the convolutions engraved on the mold – that is to say, the outside diameter of the green tire is a little less than the diameter representing the deepest indentation in the rim when finished. The steam bag is then inflated with steam upward of

*The data for this article were secured during a lengthy inspection of operations with Joseph Torrey, manager of Goodyear's Development Service, who has been in intimate contact with the tire mold problem for many years. Thanks are also due to Goodyear Tire & Rubber Co. for the illustrations.

Fig. 1 – A Section Across a Green Tire as It Is Placed on the Barrel of a Tire-Building Machine – 4 Plies, Tread at Center, Beads at Either End

Molding a Tire

155 psi., which expands the green tire radially outward until it fills the mold completely, and the plastic rubber at the outside enters into all the engraving and convolutions of the mold's inner surface. Trapped air is vented to outer channels through appropriate drill holes about 0.05 in. diameter; a whisker of rubber follows, sticking up on the treads of new tires.

Almost simultaneously, superheated steam at 280 to 320° F. bathes the mold, top and bottom, and is the heating source required to bring the raw rubber up to the temperature required for the molecular changes known as vulcanizing. After a sufficient time, the operations are automatically reversed and a finished tire is ready to come out of the mold. Undercuts in the mold do not bother, for the rubber moves over elastically until it is freed; in fact, the only wear occurs around the edges of the mold where top and bottom halves register. The steam bag is then pulled out of the tire; it is trimmed, inspected, and shipped to automobile plant, warehouse, or dealer.

Such is the process of tire building, and it has not changed in essentials for 25 years despite great advances in labor-saving machinery in all steps of processing from unloading raw material clear through to the shipping platform. Furthermore, the curing time has been cut down, both by the new automatic equipment as well as by the discovery of vulcanizing accelerators which are chemicals added to the green rubber. Fifteen years ago it took an hour to cure an automobile tire; now the floor-to-floor time is more like 15 min. (Specific data in this article, representative of a passenger automobile tire, are varied according to the size of the tire and the formula used in the compounding department.) Durability in terms of tire miles is being continually increased; tread designs are almost without limit. Joseph Torrey of Goodyear's Development Service estimates that an average of at least two new experimental or production designs have appeared every week for the last 12 years. If a new tire design is adopted by a popular make of automobile, hundreds of molds for that design must be promptly made and supplied to the tire factories. In automobile tires the emphasis is on such characteristics as nonskid and silence – tires which do not squeal or throb at any speed on any road surface. Such requirements have resulted in an amazing intricacy in tread convolutions.

Fig. 2 – Cross Section of Green Tire Just Before Entering Mold (Horseshoe Section) With Steam Bag Inside

MOLD CONSTRUCTION

Perhaps the reader can now appreciate the situation in the middle 1930's which convinced Goodyear's management that tire molds would constitute a serious bottleneck unless some radically simpler process than engraving out of solid steel could be devised. About 50 million tires were made by the American industry that year (production is now about 85 million) and literally hundreds of new designs and sizes were being developed yearly.

As noted, the standard method at the time was to engrave the tread and sidewall embossing on the inner curved surface of a steel mold. The engraving machine primarily roughed out the repeated elements of the design. Its limitations were obvious; much hand finishing was necessary. Even in prewar dollars, the average cost of a new mold was about $800; worse, either a new or an old design could not be completed in less than six weeks.

It was something more than a lucky accident that Burgess Darrow, then Goodyear's development manager (now retired), had visited the Continental Rubber Co.'s plant in Hanover, Germany, in 1934, and found them "figure casting" tire molds of iron. Patterns were rather complicated assemblies of plaster of paris segments; molds were sand. He brought back some samples and an idea for an entirely new approach.

The apparent alternative to engraving or machining from the solid was to cast the required surface. But how make a pattern which could be drawn? A bowl with radial protuberances around its rim would obviously require a multitude of retractable parts, each withdrawing outward at its own angle away from the center; this didn't look practicable

Search for Simpler Mold-Making

to any foundryman except for very coarse convolutions on tire treads. A second alternative was the lost-wax process used for centuries by art foundries to cast objects with extensive folds and overhangs. The wax models would require metal dies in which to cast the wax segments, and the problem of *draft* again arose, unless the circumference were divided into 50 or 60 segments. A degree of accuracy unknown to statuary makers was also necessary before so many wax segments could be assembled into a circle within the necessary tolerances. Nevertheless, the lost-wax process was given a trial but proved to be disappointingly expensive and time-consuming.

A third (the successful solution) was to use an elastic pattern, cast in a "core box" which is an exact replica in plaster of the finished tire or a segment of it. A plaster mold or perhaps even a sand mold could be made from this elastic pattern, if the pattern were elastic enough so it could be "drawn" despite moderate overhangs. The tire mold could then be cast in either iron or aluminum by conventional methods. It is realized that this scheme involved four direct or mirror replicas – namely, model, elastic pattern, mold, final casting – and a correspondingly high degree of accuracy in each operation if the result were to reach an acceptable tolerance of 0.0005 in. per in.

The plaster model and the plaster mold, therefore, seemed worth studying, and A. C. Gunsaulus (then in charge of mold design and now manager of wheel and brake development for Goodyear Aircraft Corp.) was assigned the job. His first task was to find a man who knew a lot about plaster molding and an enterprising foundry which could cast metal in plaster molds. He was fortunate to discover the first in nearby Cleveland

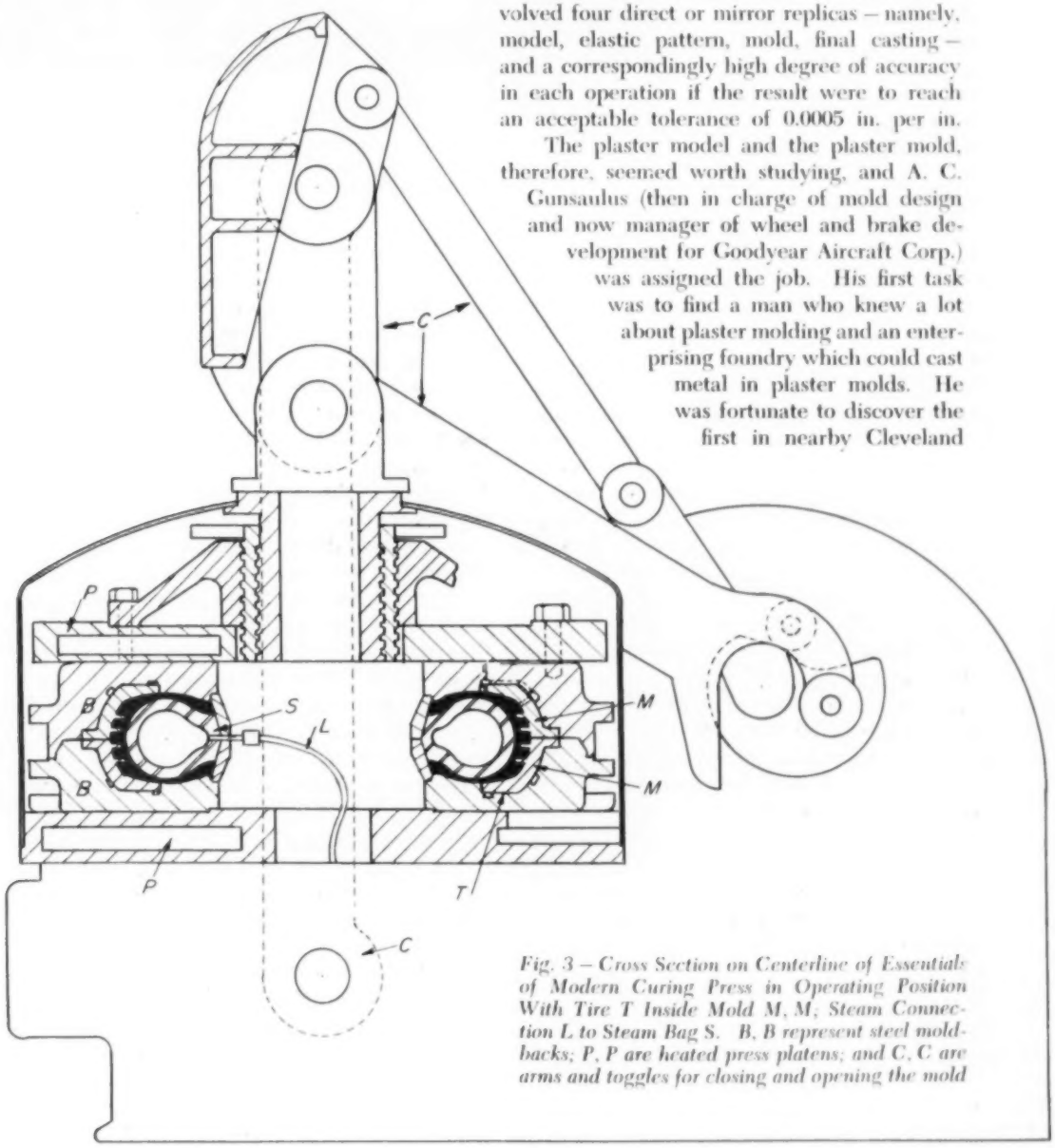


Fig. 3 – Cross Section on Centerline of Essentials of Modern Curing Press in Operating Position With Tire T Inside Mold M, M, Steam Connection L to Steam Bag S. B, B represent steel moldbacks; P, P are heated press platens; and C, C are arms and toggles for closing and opening the mold

in the person of Albert H. Haller, a statuary molder who had started life as a toolmaker. Haller had just finished models of several bronze architectural details for the National Archives Building in Washington, and the casting had been made in the Antioch Art Foundry at Yellow Springs, near Dayton, Ohio, under direction of Morris Bean. Thus it was that the team of Gunsaulus, Haller and Bean was assembled and devised the system now used so successfully for casting tire molds in aluminum.*

Fig. 4 – Sweep for the First Stages in the Making of a Mold. Gray inner shape is a surface representing bottom of deepest grooves in finished tire; white outer shape is the correct outer form of the tire

It would be tedious to recount the various steps, trials and errors which occurred during 1934, 1935 and 1936, and the mutual influence of design, model, pattern and casting method on the final techniques. Naturally enough, the progress was from a simple design to one more complex. In this article an attempt will merely be made to describe how a plaster model is now made from a design drawing, how a mirror replica of this model is made of a rubbery material, how this mirror replica is used to make a segmental mold in plaster of paris by the Antioch Process.† Lastly, a short account will be given of the die casting of tire mold segments as practiced at Goodyear's No. 1 Plant in Akron, Ohio. As indicated in Fig. 3, the resulting tire mold is split on its central plane and each half is a composite – a husky steel mold-back takes the main loads, and this is lined inside with a series of segmental "inserts" which actually form the corrugations to be reproduced in rubber. Most of what follows will be a description of how these segmental "inserts" are cast in aluminum.

Making the Plaster Model – Space limitations will not permit the reproduction here of the complicated drawing from which a mold is to be made. In a tire of advanced design the "diamonds" on the tread are not all equal in size; the grooves between are not uniform in width for their entire depth; their sides may be undercut; the bottoms of the grooves are not necessarily smooth. No less than 40 details may be drawn and dimensioned to 0.001 in. to specify one segment of the 51 which comprise the complete circle of a tire of recent design. Variations in the tread, point to point around the circumference, prevent singing or roaring by harmonic vibrations against road surfaces; the general arrangement of ribs and corrugations gives good traction under any condition of weather; bottom fillets, smooth and correct, discourage fatigue cracks. One segment may repeat itself around the circumference; more likely there is also a second or even a third segment wherein the convolutions are arranged in different order, and these occur not alternately but in random around the finished tread – here again to break up harmonic vibrations at all operating speeds.

The task is to model such a design full size and with an accuracy of about 0.001 in. in all directions – so good that light will not show between model and edge of its proper section templet. As now practiced at Goodyear's Akron factory in a department still headed by Mr. Haller, the first thing is to sweep a quarter-circle in a gray cement-plaster mix (such as "Hydrocal") to a surface represented by the *bottom* of the grooves – the near portion of Fig. 4. The sweep is sheet steel with edge

*It might also be mentioned that some years ago U. S. Rubber Co. publicized a method of electroforming, where a thick iron electroplate was deposited over a conductive elastic replica of the tire's surface, stripped, and backed up by metal thick enough to give it necessary strength.

†The Antioch Process was briefly described in "Critical Points" in *Metal Progress* for March 1952.

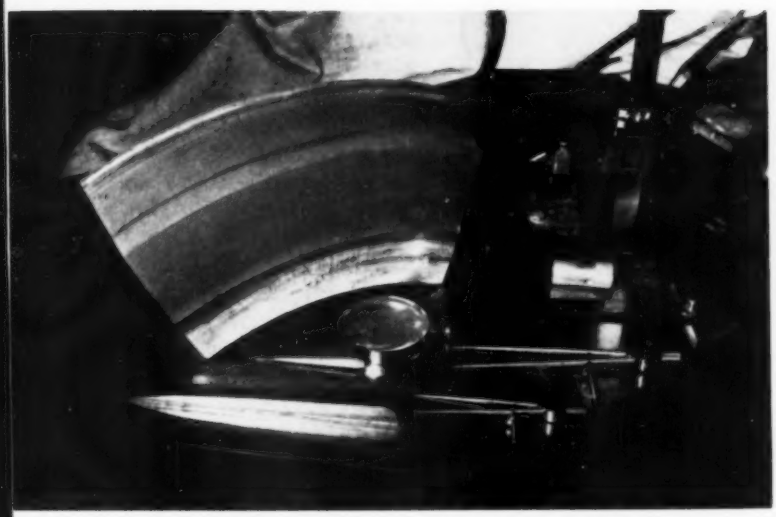


Fig. 5 – Segment Made From Fig. 4 After Layout Artist Has Drawn Pattern on Outer Surface. Some of the instruments used by him in making the three-dimensional layout are also shown

chamfered back at 15° on each side. Figure 4 shows the equipment and method better than words can describe. The colored cement sets into a hard body which resists scratching by the engraver's tool in later operations, and its gray color tells his eye that the limit has been reached.

After 45 min. for hardening, this foundation is then overlaid by a plaster of paris body swept to the correct *outer* shape of the tread. (This same sweep would also cut any straight circumferential grooves which might appear in the tread design.)

The layout artist is a draftsman (no, a mapmaker) in three dimensions, for he must transfer the designer's ideas to the curved surface of the model with mapmaker's precision. Instead of a pencil he uses a needle-like stylus for scratching the firm plaster. The result is photographed in Fig. 5.

Lastly, the grooves so outlined are cut into the plaster rim by hand by a scalpel-wielding craftsman (Fig. 6). In this work he is guided constantly by templets cut of 0.032-in. zinc sheet. His work is done under a single bright light in a darkened room, for the surfaces must be so accurate that no light shines between templet and finished surface. An idea of the intricacy of this work may be realized from the gages (on the table in Fig. 6) that the engraver needs to reproduce the tread design. At the end a segment of the tire tread is reproduced for from 7.2 to 15° (1/50th to 1/24th the circumference), an angle depending on the frequency with which the design repeats itself.

Such a model could be made in wood, by usual patternmaker's operations. The advantages of plaster are *(a)* its lack of directionality or fiber, *(b)* its fine uniform grain, *(c)* its ready yielding to the engraver's knife, *(d)* its permanence of dimension despite the effects of age, changes in temperature and changes in humidity.

The Plastic Pattern – We now have a three-dimensional replica of a portion of a new tire's tread. The next thing to do is to make a pattern (negative) from it, suitable for foundry use. Here is where Morris Bean came up with another idea. He proposed using the plaster model as one surface of an appropriately shaped "core box" and pouring in enough of a rapidly setting plastic to fill it.

Fig. 6 – Cutting the Grooves in a Partly Finished Model. Note appropriate tools and templets which the engraver uses to guide him into the correct forms. (Photo courtesy Akron Beacon Journal)

Fig. 7 – Upper Left Is Korogel Tread Pattern Backed With Hydrocal, and Just Below It Is a Plaster Mold Made Therefrom. At center are shown similar pattern and mold for the rear surface. At right, above, are the two, assembled with sprue, and at bottom right is the aluminum casting (insert) after breaking away the mold

The first successful material (and still extensively used in this way) was "Korogel",* a rubbery plastic developed by B. F. Goodrich Co. We would now call it a thermosetting plastic; chemically it is polyvinyl-chloride which solidifies at 275 to 300° F. into a strong body about as flexible as stiff gelatin would be.

Korogel does not stick to varnished plaster, reproduces the form perfectly, has a vanishing amount of shrinkage and is strong and elastic enough to be easily drawn after solidification without breaking the plaster model. Likewise, when this casting of Korogel is used as a pattern (Fig. 7) it can be successfully drawn from a gypsum-sand mold, as made by Morris Bean's Antioch Process. It will be remembered that the mold is formed of a 50-50 gypsum-sand mixture originally of thick, creamy consistency, and no force other than gravity is used in the mold as it is setting hard.

The Segmental Inserts for a Tire Mold – In the adaptation now used in Goodyear's foundries, an investment impression is made from this Korogel pattern and is assembled with another recrystallized plaster investment reproducing the back surface of the required casting (center of Fig. 7), and the two when assembled provide the cavity into which aluminum alloy can be cast. The casting is broken out, cleaned, gates and risers cut off, edges milled at the correct angle, and the required number of segments inserted in a steel mold-back and bolted down with countersunk studs around the parting surface between top and bottom halves of the completed tire mold. This assembly is indicated in Fig. 8.

The upper half of the complete tire mold is constructed similarly (as described in the previous account of how a tire is made, and indicated in Fig. 3). It will be remembered that only the *outside* of sidewalls and rubber tread of the finished tire are formed against the metal mold; the inside is shaped by the pressure of the air bag during the curing cycle.

FULL-CIRCLE TREAD RING

An alternative method is practiced at the Antioch foundry. Here Morris Bean makes a series of gypsum-sand molds from the Korogel pattern, each one an accurate segment of the tire's surface, and assembles them into a circle, indexed, and aligned by a sweep around a central shaft. This is covered with a round gypsum-sand ring, molded to the correct shape (with allowance for machining) for the back where it fits against the mold-back (steel bowl). The assembly is properly bound together and cast in aluminum alloy. Thus, instead of casting a number of segmental inserts and assembling them in a circle, the segmental molds are assembled and a ring-shaped casting made. These "tread rings" are later fitted and secured to steel mold-backs and form either top or bottom part of the tire mold. (See Editor's note on opposite page.)

The 5% silicon-aluminum sand-casting alloy No. 43 was originally used for its good found-

*Korogel is rather too plastic to retain its form accurately as a pattern when rammed in sand. Mr. Gunsaulus said that Goodyear's first successful "figure-cast" tire mold was cast from plaster patterns, rammed up in sand. This work was done by the late John Harsch, Sr., in his aluminum foundry in Cleveland. This was for a tractor tire with coarse corrugations. Another source of sand-cast tire molds during World War II, when aluminum was scarce, was the Overmyer-Mould Co. at Winchester, Ind. This firm specialized in the manufacture of iron molds for fancy glass objects, cast in sand cores.

ing qualities, but it is very "gummy" in the machine shop, so that the more readily machinable, permanent-mold casting alloy No. 214 (4% Mg) is now ordinarily used, both for the complete rings made at the Morris Bean foundry for Goodyear and for the tire industry generally. This alloy is also used for the segmental cast inserts made by Goodyear in similar plastic molds for its own requirements.

Another reason for using alloy No. 214 is its excellent corrosion resistance. These tire molds – especially in the early 1940's – were frequently quenched after the curing cycle to hasten the process, and the water was often contaminated. As a matter of fact, corrosion of the working surface of the tire mold is no great problem; neither is wear – the only damage to the surface might come from rough handling or an accident. Another matter which caused foreboding was the possibility of electrolytic corrosion between aluminum inserts and their supporting steel bowl – this is controlled either by doping the contacting surfaces with heat resistant aluminum paint – or, under extreme conditions, by metallizing the inner surface of the steel mold-back with aluminum.

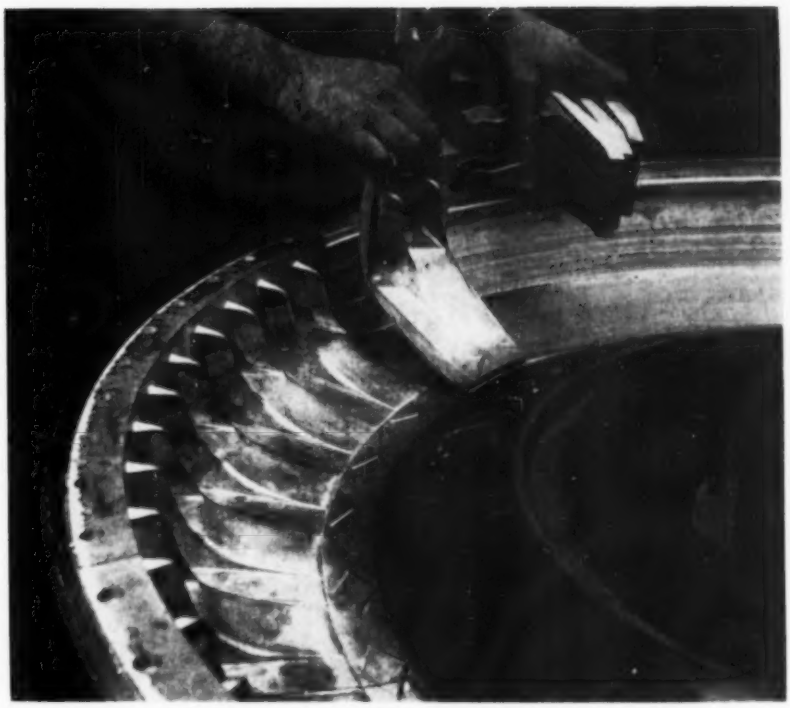


Fig. 8 – Assembling Inserts for a Heavy-Duty Truck Tire in a Steel Mold-Back. The segments are bolted down with countersunk studs around the parting surface. (Photo courtesy Akron Beacon Journal)

DIE-CAST INSERTS

It remains to be said that the popular designs and sizes for tires sold in such numbers that dozens – even hundreds – of tire molds must be supplied to the various Goodyear factories are made with die-cast inserts. Die casting alloy No. 13 (12% silicon) is used, but H. G. Sutherland, foreman of the department, says that through repeated use of reclaimed metal the iron content has reached the limit where it sludges out in the melting pot. Despite this contamination, it seldom takes much time to adjust gates and vents until good castings with sound, smooth surface emerge. Minor internal porosity is not a rejectable defect. Such extreme iron contamination is encountered only under emergencies such as the aluminum shortage during the war. Normally, iron contamination is held within acceptable limits by sweetening the reclaimed metal with new alloy ingot.

Three ordinary gooseneck die-casting machines are installed in this department. The fourth machine (shown in Fig. 9) takes two dies mounted on a turntable. While the one at the right is locked in the machine for casting an insert, the other is exposed, open, so a workman can place the steel blades that are to be cast into the insert and later form slots in the tire tread no wider than 0.010 to 0.020 in. (The two dies may be somewhat different in arrangement, even though they form segmental inserts for the same tire mold.) Such a die

*Editor's Note – P. H. Brotzman, metallurgist for Firestone Tire & Rubber Co., informs me that similar molding methods are used by his firm to cast tread rings in ductile iron. They are made slightly undersize and are expanded by forcing them down over a conical mandrel to exact diameter. In his opinion, iron is superior to aluminum because it avoids corrosion couples when impure cooling water must be used, and the iron is much more resistant to rough handling or accidental damage – as from a falling wrench.

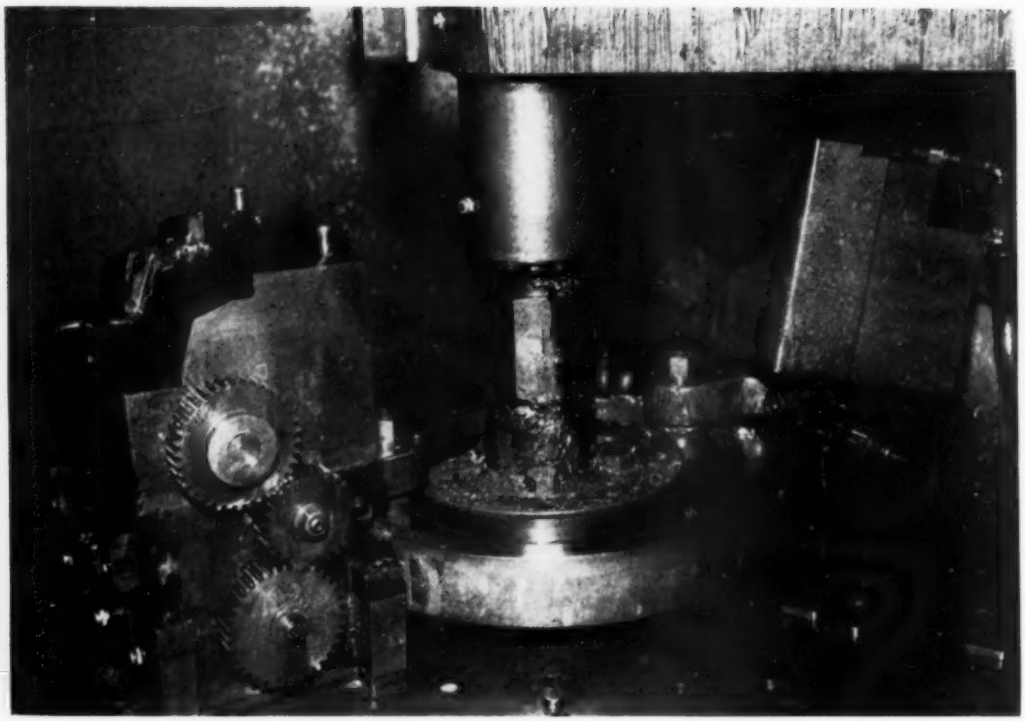
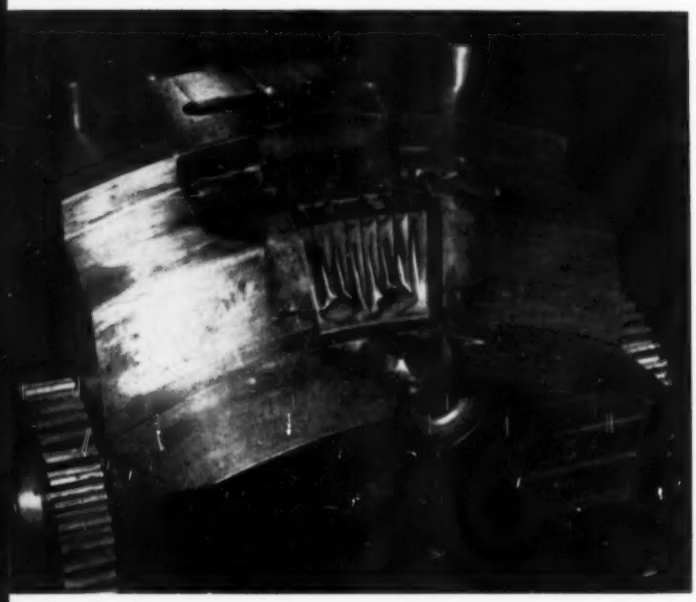


Fig. 9 – Turntable Attached to Casting Machine Carrying Two Dies, Each With Retractable Portions. While die at right is in position for casting an insert, die at left is exposed so workman can place thin steel blades (better shown in Fig. 10)

Fig. 10 – Close-Up of Exposed Die (Left of Fig. 9) Taken From Different Angle to Show Thin Steel Blades Which Will Be Cast Into the Segmental Insert



with retractable parts is formed of a dozen or more highly accurate parts, and is a notable example of the toolmaker's craft.

CONCLUSION

A fitting conclusion to this article might be an account of the wartime adaptations of the gypsum-sand molding process for all sorts of military hardware for ordnance and quartermaster. Sticking, however, to the subject of tire molds made in emergencies, it may be said that many new designs for airplanes or military mobile equipment from jeeps to tank transporters were put into production in a matter of weeks, whereas months would have been required for engraving the molds in the manner used prior to 1935.

Likewise, during the times when the rubber supply was tight in the early 1940's, Goodyear was able to modify its molds so as to reduce the thickness of rubber on the tread and thus effect a major economy merely by machining down the outer surface of the plaster model and recasting the tread rings or inserts, where otherwise completely new sets of molds would have been necessary. Beyond all that, the method described may be worthy of use by other industries when intricate castings of high precision must be had.

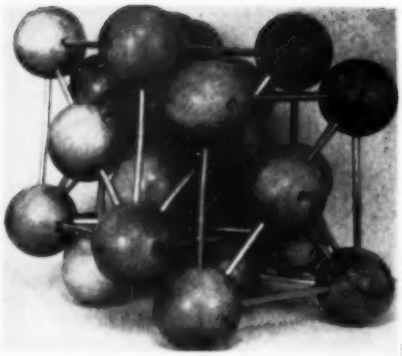


Fig. 1-A – Lattice Structure of Silicon Is That of Two Interpenetrating Face-Centered Cubes

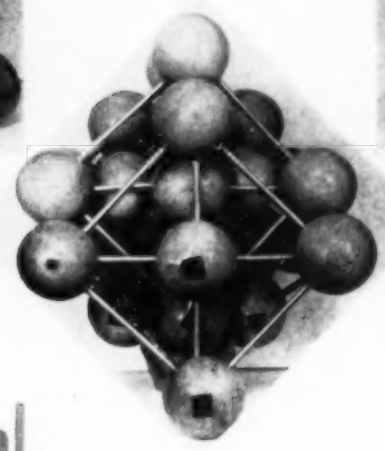


Fig. 1-B – Basic Tetrahedron, Indicated With Black Patches, Has Coordination Number of 4

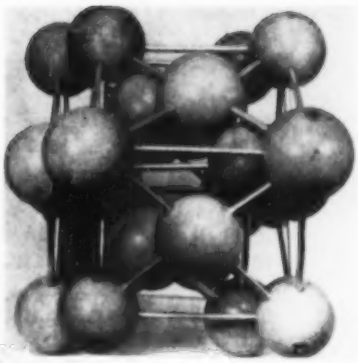


Fig. 1-C – Large Voids Exist in the Lattice

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Armour Research Foundation
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Chicago

An Appraisal of Silicon and Its Alloys*

SILICON is the second most plentiful element in nature, ranking in abundance next to oxygen. It constitutes about 26% of the total material in the earth's crust, oceans and atmosphere, and always occurs in the combined state. In this form the silicates are the major constituents of most of the important rocks. Silicon is not a metal, but a semiconductor, similar in nature to diamond and germanium, and is characterized by a negative temperature coefficient of electrical resistance. It has a metallic luster and a silver color. The uses for silica and the silicates are tremendous, but the commercial uses for the element, silicon, are relatively less extensive.

The largest use for silicon is as an alloying and deoxidizing agent in steelmaking operations. It is also used as an alloying agent in copper, aluminum, and nickel alloys. In most of these, silicon is added in the form of a master alloy; this is usually prepared by the reduction of silica or silicates by solid reducing agents, such as carbon or aluminum, in arc furnaces. The physical properties of these master alloys have had little study; however, since they are used exclusively for alloying or deoxidizing purposes, the only property of interest is their composition. Relatively recently, the use of silicon and germanium as the crystal in crystal rectifiers has become such an important development that basic study of the pure elements has been encouraged.

Production – Despite its abundance, silicon has not been studied extensively, probably primarily because no large-scale commercial uses were evident. The first partially successful attempt to isolate it was made in 1808 by Berzelius, who reduced silica with charcoal in the presence of iron to form ferrosilicon; in 1823 he produced elemental silicon by reducing potassium fluosilicate with potassium.

At present there are two basic methods for the preparation of this material. The one used in England, the Tucker process, is a straight chemical purification of a 98% silicon (produced by aluminum reduction) and consists of repeated leachings in heated solutions of min-

*This study was conducted for the Air Matériel Command, U.S.A.F., and the detailed information is contained in AF Technical Report 6383.

eral acids, principally hydrofluoric and sulphuric acid. This treatment removes most of the residual aluminum and iron to produce a silicon around 99.8+% pure. The process developed in this country by the Du Pont Co. purifies silicon by the pyrolytic reduction of silicon tetrachloride gas with zinc vapor. This reaction is carried on at about 1740° F. in a quartz retort, and the resulting product is a mass of needle-like crystals of silicon of about 99.9+% purity with approximately 0.03% carbon as the major contaminant.

Properties – At first glance, silicon appears to have very favorable physical properties. It is very light, having a density of 2.32 g. per cc., or about 15% less than that of aluminum. Silicon is also very corrosion resistant. It can be heated in air to 1000° F. and will remain bright and silvery, and it resists the action of most mineral acids. Furthermore, it is readily available and relatively cheap. But the lattice structure of silicon is not metallic.

Silicon crystallizes in a diamond lattice, a lattice type occurring only in carbon (diamond), silicon, germanium, and gray tin. This structure may be visualized as two interpenetrating face-centered cubes (Fig. 1-A) with the origin of one displaced ¼ atom distance along the body diagonal to the other. Thus each atom is surrounded by four neighbors to form a tetrahedron, Fig. 1-B. The bonding between atoms is covalent; each atom has four valence electrons in its outer shell. Each pair of atoms shares two electrons with each of its four neighbors to produce the effect of a filled outer electron shell, which confers on silicon its chemical inertness. It may be noted in Fig. 1-C that this lattice type contains considerable void space and is definitely not regarded as a close-packed lattice.

There appears to be no polymorphism in silicon analogous to the transformation of gray to white tin, despite some indication found by early investigations. Recent X-ray diffraction measurements at high temperature run by the Ohio State University on high-purity silicon indicated no allotropic transformation up to 2370° F., about 225° F. below the melting point. (Virtually a straight-line relationship exists between lattice constant and temperature; these data are given in Table I.) The electrical properties of silicon are those typical of a semiconductor; resistivity is high (10^6 ohm-cm.), decreasing very rapidly with the first additions of other elements. The resistivity further decreases with rising temperatures. Conductivity occurs in the typical semiconductor movement of "holes".

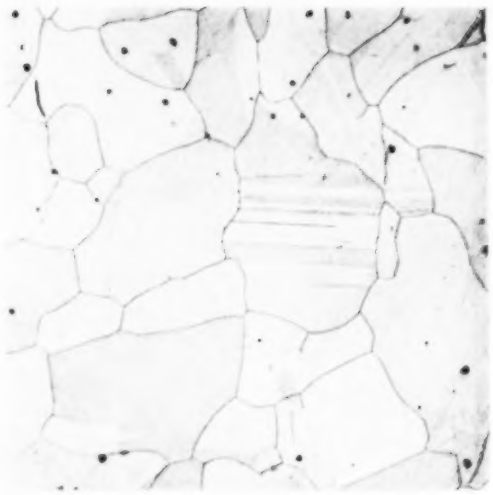


Fig. 2 – Electromet Silicon, Atomic-Hydrogen Melted and Arc Remelted. Etched with 60% HNO_3 + HF; 250 ×

No evidence of metallic ductility has been found.* Silicon fractures in a typical brittle manner. The microstructure of the high-purity material generally shows a considerable amount of twinning, Fig. 2. It is believed that twinning occurs during cooling from the melt, for there is appreciable expansion in the solidification of silicon. This expansion may be clearly seen in Fig. 3, which represents a number of silicon-iron alloys with decreasing iron.

Principal Uses – Silicon is used as an alloying and deoxidizing agent for a number of metallic systems. The large tonnage use is in the deoxidation of steel in the openhearth process. It is also used as an alloying agent

Table I – Lattice Constant Versus Temperature†

Temperature	Lattice Constant
32° F.	5.4190 a_o
86	5.4195
1342	5.4335
1638	5.4388
1816	5.4390
2080	5.4428
2405	5.4467

†Data determined by G. B. Skinner, J. W. Edwards and H. L. Johnston, Department of Chemistry, Ohio State University.

*Very recently, General Electric researchers have found evidence of appreciable ductility of silicon and germanium transistor material at elevated temperatures. The deformation apparently occurs by slip.

to the extent of 2 to 5% in iron to make special transformer core materials with improved magnetic properties. Certain aluminum-base casting alloys contain up to 12% silicon (as in S5, A132 and red X13 alloys) to improve the fluidity of the metal. It also is added in a number of copper and nickel alloys as a hardening agent.

For use in crystal rectifiers, silicon must be modified by the addition of another element to increase its conductivity. This addition is very carefully controlled so that the properties of the resulting crystals are optimum. These crystals are becoming increasingly important in the electronic field, but the over-all use of silicon in crystal rectifiers is infinitesimally small in terms of total production. Furthermore, germanium has now largely replaced it in this particular field.

Siliconizing, or the impregnation of the surface of metals with silicon, is attracting considerable interest. Siliconized iron possesses excellent corrosion resistance in certain applications, and the siliconizing of molybdenum is said to afford a measure of protection against high-temperature oxidation.

Silicon-Base Alloys – The study of the constitution and properties of high-silicon alloys has been sparse because cursory examinations had revealed no useful properties. Under the sponsorship of the Air Matériel Command, experimental work was carried out by the Armour Research Foundation of Illinois Institute of Technology on the properties and constitution of the silicon-rich regions of a number of binary systems.

The experimental preparation of silicon-base alloys was carried out by arc melting under inert atmosphere in a nonconsumable electrode furnace. The silicon melting stock was 99.89% silicon prepared by a chemical purification process by the Electromet Division of Union Carbide and Carbon Corp. This was prepared for arc melting from 30 to 80-mesh powder by premelting with an atomic-hydrogen torch. Premelting converted the powder with minimum contamination into lumps which could be easily handled in the arc furnace. There is some tungsten contamination from the electrode tip, particularly with the highest silicon alloys, but this impurity is easily identified as WSi_2 in the microstructure.

The following general features of silicon-rich systems apply:

1. There is a complete miscibility in the liquid state of silicon and all metals with the exception of bismuth, lead, thallium, and possibly zinc, cadmium and indium.

2. There appears to be no measurable solid solution of any metal in silicon (germanium forms a continuous series of solid solutions with silicon).

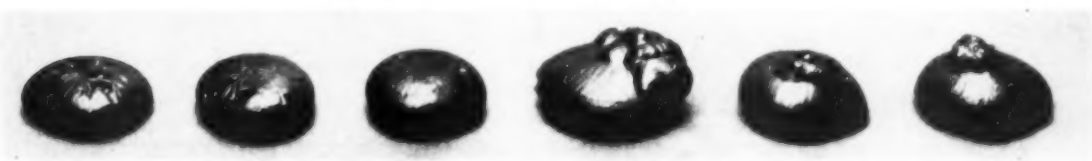
3. The alkaline metals, alkaline earths, copper, and the transition elements form one or more silicides.

4. In all known alloys, the freezing point of silicon is depressed, sometimes to a very great extent, by the addition of another element.

A number of silicon-rich binary systems were investigated; some of the resulting diagrams confirmed the literature, some corrected it, and certain diagrams added new information. These diagrams will be given in a technical paper now in preparation. Several significant features may be noted in the microstructure of many of these alloys. When a silicide in equilibrium with silicon crystallizes in massive form, it is often seen to possess a somewhat "duplex" structure of coring. One possible explanation for this phenomenon may be that some silicides are of variable composition over a limited range. Another effect is that of eutectic degeneration. Often in structures where the equilibrium diagram would predict a eutectic, none is evident. This may occur when the eutectic lies close to either silicon or the silicide; then one component of the eutectic is absorbed by its primarily crystallized parent to leave a two-phase region void of typical eutectic configuration.

A typical example of elements which do not form a silicide is given in Fig. 4 (bottom of following page), showing the silicon-aluminum system. No solubility of the aluminum in the

Fig. 3 – Buttons of Silicon-Iron Alloys



50% Fe *45% Fe* *42% Fe* *18% Fe* *9.5% Fe* *4% Fe*

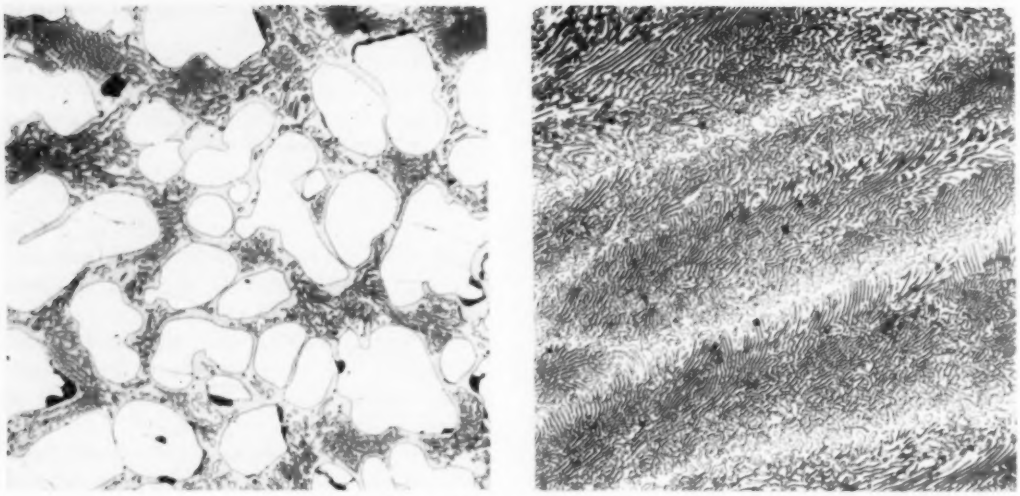
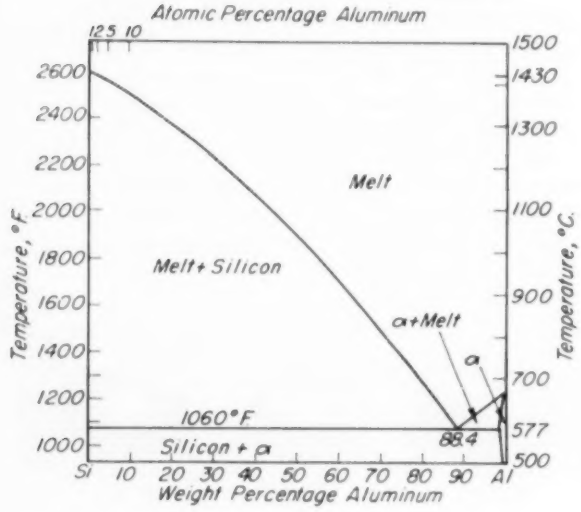


Fig. 6 — Silicon-Titanium Binary Alloys. Left is 10% titanium alloy, with primary silicon and Si-$TiSi_2$ eutectic. Right is 22% titanium alloy, typical of the eutectic structure. Etched with 2% HF + 3% HNO_3 + 95% H_2O; 250 ×

silicon can be detected. A similar diagram may also be drawn for the silicon-silver and the silicon-tin systems. Most of the elements, however, form one or more silicides (Fig. 5). In this case the silicon-rich alloys will always consist of a mixture of silicon and the silicide. There are no indications of the existence of silicides higher than the disilicide. Consequently, it appears that because of the low atomic weight of silicon no single-phase alloy can be made which will contain a very high percentage of silicon.

Fig. 4 — Phase Diagram of the Binary System Silicon-Aluminum

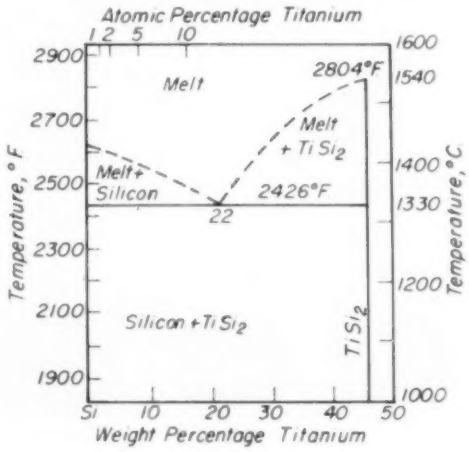


A 10% titanium alloy shows primary silicon and the eutectic, Fig. 6 (left). The 22% alloy (right) is typical of eutectic structure. Figure 7 shows primary disilicide in a matrix of degenerated eutectic in a 17% silicon-vanadium alloy. Note the cracks in the brittle disilicide.

Some of the silicon-manganese alloys showed peculiar microstructures in the region of the disilicide, which occurs around 50% silicon. This appeared as a pattern of parallel lines in each grain, Fig. 8, for which no explanation has been found.

Microhardness measurements were made on a number of the disilicides in the course of this

Fig. 5 — Phase Relationships in Silicon-Rich Silicon-Titanium Alloys



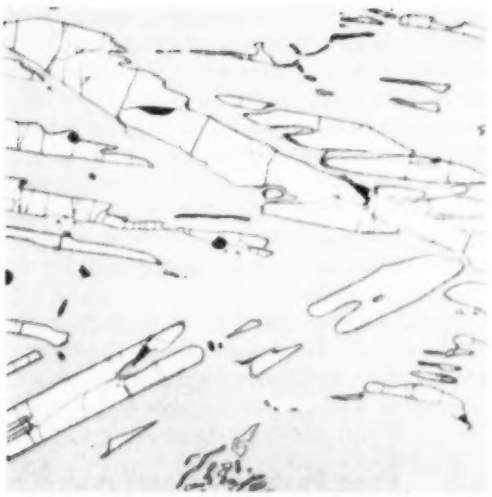
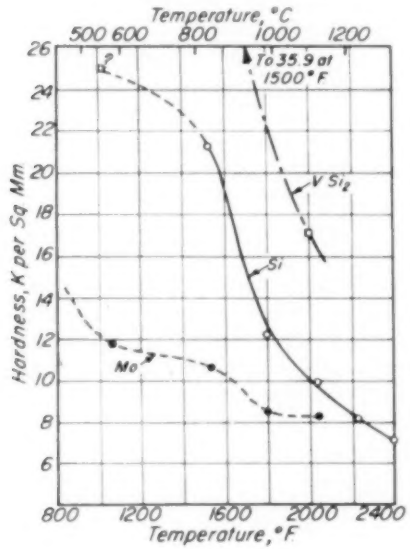


Fig. 7 – White Areas Are Primary Crystals of VSi_2, Gray Matrix Is Degenerated Eutectic in 17% Vanadium, 83% Silicon Alloy. Etchant: 40 parts H_2O, 10 parts HNO_3, 5 parts HF; 250 ×

work. In general, the compounds showed slightly lower hardness values than silicon and somewhat less tendency to crack around the diamond indentation, but in no case were the hardness values low enough to encourage any hope of room-temperature ductility in the disilicides. These hardness values range from Knoop (300 g.) 550 for $NiSi_2$ to over 1300 for Mo_3Si and V_3Si. The average Knoop hardness values for a number of readings for silicon were 950 (using a 300-g. load). Some investigators have reported signs of ductility in certain silicides made from the gaseous phase, but this could not be confirmed with cast silicides.

Some hardness measurements were carried out on silicon at elevated temperatures and also on vanadium disilicide. The results may not be too accurate since a nonstandard testing technique was used (see "Simple Tester for Hardness of Hot Materials", by R. F. Domagala and W. R. Johnson, *Metal Progress*, December 1951, p. 72), but there is a definite indication that silicon and its disilicides decrease in hardness at higher temperatures (Fig. 9). There was no evidence, however, that silicon could be deformed plastically at the higher temperatures. For example, indentations made in molybdenum always produced bulging around the indentation but silicon never exhibited this type of behavior.

Fig. 9 – Hot Hardness of Silicon



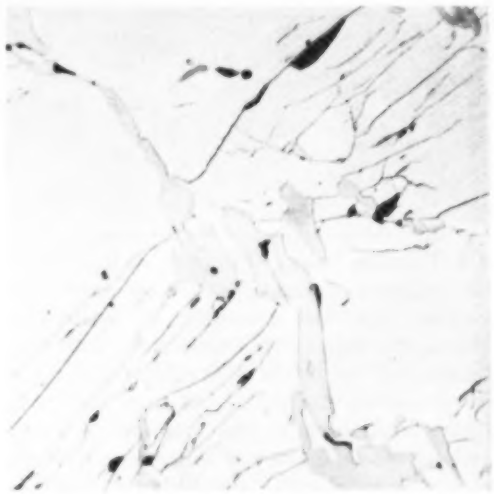


Fig. 8 – Primary $MnSi_2$ (Parallel Line Pattern) and Si-$MnSi_2$ Eutectic (Degenerated) in 50% Manganese, 50% Silicon Alloy. Etchant: 40 parts H_2O, 10 parts HNO_3, 5 parts HF; 250 ×

Summary – Silicon, despite its advantages of availability, low cost, low density, and high corrosion resistance, does not appear to offer promise as an engineering material. It possesses the typical brittle characteristics of a diamond crystal structure, and no prospect is in sight for causing a polymorphic transformation to a metallic lattice. Furthermore, all silicon-rich alloys appear to be two-phase, with brittle silicon the major constituent. The highest single-phase alloys, the disilicides, are not truly high-silicon alloys nor are they ductile.

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Central Alloy District
Republic Steel Corp.
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Recent Improvements in Electric Steelmaking

About 800 men registered at the tenth Electric Furnace Steel Conference of the American Institute of Mining and Metallurgical Engineers, held last December in Pittsburgh. During the three days' meeting the following timely and important topics were discussed: fume control, gas-heated hot tops, rare-earth metals for deoxidizers, "auto-pouring" of ingots, and substitute sources of chromium for low-carbon stainless steels. Notes on these matters will now be presented.

FUME CONTROL IN THE ELECTRIC FURNACE SHOP

Code authorities are continually writing stricter regulations to cut down atmospheric pollution. In the opinion of J. G. Liskow of American Air Filter Co., Louisville, Ky., hoods can be effectively used on smaller electric furnaces. Basically, the hood size is governed by roof-ring diameter. Extensions over the charging or slagging doors and the pouring spout, besides the hood itself, together with a means of exhausting air and cleaning it of dust and fume, constitute the problem. An added condition is that the electrodes must go through this structure and not touch it. Nevertheless, it appears that control of dust and fume at electric furnaces is entirely practicable. Wet collectors can reduce dust and fume in the discharge to 0.3 to 0.4 grain per cu.ft., a figure which meets or betters most present code requirements but does not always meet the ideas of officials as to smoke "elimination". Most particles in fume and smoke from a furnace are less than 0.5 micron in size, and efficiency of wet collectors is only about 50% on so small a particle. The average particle size for total emissions (fume, smoke and dust) is between 2 and 5 microns, but many of the particles are as small as about 0.2 micron.

There are two possibilities to reduce discharge of very fine material to the atmosphere, both of them highly developed during the last 50 years by the nonferrous smelting industry — *(a)* the Cottrell type of electrostatic precipitator, which uses metal only, and *(b)* the cloth filter or bag house, wherein the cloth must be able to stand temperature peaks of 900 to 1000° F. during a furnace boil, or be protected by a precooler. A spark arrester must also be installed unless glass or asbestos fabric is used.

M. I. Dorfan of Mechanical Industries, Inc., Pittsburgh, also presented a paper on a unique method of collection for electric furnace fumes. Of interest were the following facts:

Gases from small electric foundry furnaces may amount to 4000 to 6000 cu.ft. per min. per ton of material processed per hour. Furnace emissions of 5 to 8 lb. of particulate matter per ton of metal melted may be anticipated.

Fume particles are predominantly spherical, mostly smaller than 3 microns diameter and with 95% below 0.5 micron.

Dust characteristics and operating conditions for the larger furnaces are similar to those for the smaller ones, but fume losses are higher, being 0.5 to 0.6% of process weight.

Some difficulties have yet to be overcome on hooding of larger furnaces, particularly to collect fume more completely, and to withstand high temperature and corrosion. It appears that the utility of a dust collector and the enthusiasm for it vary inversely with the diameter of the furnace.

Mr. Dorfan recommends that two carefully located outlets be made in the furnace roof through which the fume is piped to cyclone dust collectors followed by a special filter in which a constantly moving body of granular material flows countercurrent to the fume and gas stream after the latter is cooled to 500° F. by atomized water sprays.

An electric furnace of 25 tons capacity and 14 ft. 3 in. outside diameter at the Timken Steel & Tube Division's melt shop at Canton, Ohio, is equipped as recommended by Mr. Dorfan, and motion pictures were shown of the unit in operation during meltdown by Walter Assel, chief engineer. Wet scrubbers were not considered desirable due to local water shortage; therefore, the granular-flow, continuous type of filter using prepared steel chips was installed. At the present time a practical system for large electric furnaces is not yet in operation, and the present experimental fume-removal equipment on the 25-ton furnace operates intermittently. The basic principles, however, are established.

Victor Zang, vice-president of Unitcast Corp., Toledo, Ohio, stated that hooded fume control was installed in 1949 on five electric furnaces with shell diameter of 9 ft. About 98% of the smoke is collected. The fume loading was 0.35 to 0.37 grain per cu.ft.; after processing through Type N Rotoclones less than 0.10 grain per cu.ft. is left in the atmospheric discharge; if the particle size is less than 0.5 micron brown fumes are eliminated.

John Harrod of U. S. Steel Corp. described efforts to control fume at No. 2 Electric Furnace Shop in Chicago. The melt-shop atmosphere only is cleaned. Maintenance of the furnace hood is relatively inexpensive. One objectionable feature was longer time for roof changes, some 50% greater than normal. A fewer number of roof changes were necessary, undoubtedly due to the absence of the usual layer of roof dust and its insulating effect.

RARE-EARTH ALLOY ADDITIONS TO STEEL CASTINGS

Of considerable interest in the foundry sessions was the effect of rare-earth elements as additions to common grades of steel. G. A. Lillieqvist, research director, and C. G. Mickelson, assistant, of American Steel Foundries, East Chicago, noted that very little information is in the literature, but gave the results of their own investigations on "Lan-Cer-Amp Alloy".

Best mechanical properties on common cast steels were obtained when rare-earth alloy additions were made in the amount of 2 lb. per ton after the aluminum deoxidation. Three steel compositions – grade B steel, high-tensile steel and 1040 – were investigated. When normalized at 1650° F. and tempered at 950° F. for 2 hr., all ductility and impact figures were improved by rare-earth additions.

Tapping a 35-Ton Heat of Molten Steel From a Heroult-Type Electric Arc Furnace at Crucible Steel Co. of America, Midland, Pa. (Courtesy Westinghouse Electric Corp., manufacturer of the regulator for controlling electrode position)

The effects of rare-earth elements on the ductility and the impact properties of these steels in the water-quenched and tempered condition was even more pronounced. The possibility that end-quench hardenability was also increased was investigated, but results were negative. The additions did not eliminate temper brittleness, as determined by impact tests at room temperature and at —40° F. on a 0.30% carbon, 1.60% manganese steel produced with and without rare-earth metals.

Additions of 2 lb. Lan-Cer-Amp alloy per ton changes Type III nonmetallic inclusions to the globular, dispersed Type I. However, this change in nonmetallic inclusions is not the entire reason for the beneficial effects on duc-

tility and impact, since other means of deoxidation can change the inclusions in a similar manner without causing the same improvement in ductility and impact.

The effect of rare-earth metal additions on resistance to hot tearing, using the A.S.F. standard hot-tear casting, was determined for grade B steels. At the various pouring temperatures evaluated, lower ratings were shown for the treated steels, and the authors believe that the change in inclusions from Type III to Type I is at least partly responsible.

As to sulphur removal on production heats under basic openhearth operating conditions, heats tapped at 0.018 to 0.019% sulphur would be reduced to 0.014 to 0.015% by Lan-Cer-Amp treatment in the ladle. Experience with heats from an 8-ton acid electric furnace has not been too consistent, although drops in sulphur as high as 0.017% have been obtained. The additions may have increased the end-quench hardenability.

Rare-earth metal additions had beneficial effects on porosity, weldability and feedability.

While Lan-Cer-Amp is not a panacea for steelmaking problems, it has helped to improve many properties and thus far has shown no detrimental effects in production heats.

GAS-HEATED HOT TOPS

Heating of ingot mold hot tops with an oxy-gas flame has been cooperatively investigated by Firth-Sterling, Inc., and Linde Air Products Co. Work to date has shown that the usual 15 to 20% of additional metal poured into the conventional hot top can be reduced to 6 to 7%; this means that an extra ingot is made for every 12 or 13 ingots cast.

Firth-Sterling at McKeesport, Pa., as described by A. J. Texter, superintendent of melting department, uses blow-off heating tips which do not need to be water cooled. The hot-top casing incorporates a teeming hole, and is shortened so it contains only 50% the normal volume. Oxygen and natural gas at identical pressures are delivered from manifolds near the pouring platform; the gas ratio remains constant; gas ratio of 1.4 oxygen to 1.0 natural gas is usual, but the exact gas ratio and timing of the flame must be determined by experiment for each grade of steel and ingot size, else chemistry and ingot soundness may be disturbed. Ten minutes of heating may be enough for an 8¾-in. square ingot, and up to 15 min. for a 13⅜-in. square ingot. Preferred practice is to preheat the hot-top casing in a furnace prior to teeming; this reduces the gas requirements by some 40%. A protective slag cover between molten metal and flame has been tried; however, none of any artificial slags are as beneficial as the blanket of molten hot-top brick that runs down during heating.

Mr. Texter stated that gas hot-topping is beneficial to austenitic, martensitic and ferritic stainless steels. The ingot chemistry is not impaired and a sound macro-etch is obtained throughout the entire ingot. Steels with high carbon or analyses high in silicon and manganese require more critical attention due to the ease with which these elements may be oxidized and the top of the ingot filled with blowholes.

H. M. Evers, metallurgist for Universal-Cyclops Steel Corp. of Bridgeville, Pa., discussed use of a water-cooled torch on stainless ingots of Types 410, 405, 430, 321, 347 and 19-9 DL, cast in molds of 14x16½ in., 15x19 in. and 16 in. square cross section. The single torch produces sufficient heat to handle 14 to 16-in. square ingots using a covered hot-top casing with a center hole when the torch tip is 6 in. from the surface. Experience has shown 4 to 6% higher yields with no effect on top section macro-etch or chemistry.

Gas hot-topping as practiced at the U. S. Steel's Duquesne Works was described by B. M. Shields, chief metallurgist. A simple blow-off type of head, not water cooled, is used; a 1¼-in. pipe cap with 11 No. 30 drill holes arranged circumferentially at an angle of 27½° from the vertical gives the best flame pattern. A large mixer to handle natural gas at 45 to 50 psi. pressure is being developed for large ingots. A minimum hot top of 6 to 7% of the ingot volume is necessary for a satisfactory product. The best oxygen:gas ratio for stainless steel to minimize chromium oxidation was found to be 1.2 to 1. Heating time for large ingots (22x25 or 22x24 in.) is 1 to 1½ hr.

W. R. Lysobey of Air Reduction Sales Co. called attention to the fact that the burner should be as close to the hot-top metal as possible for best fuel economy, and hence a water-cooled tip is preferable. Three burner units operating on ingots larger than 20x20 in. generate temperatures on the order of 3000 to 3200° F. Fuel consumption on 9x9-in. ingots. was quoted as 250 cu.ft. of oxygen and 180 to 190 cu.ft. of natural gas per ton of ingots. For water-cooled burner tips heating stainless ingots

(Continued on p. 196)

Advertisement

ELECTROMET Data Sheet

A Digest of the Production, Properties, and Uses of Steels and Other Metals

Published by Electro Metallurgical Company, a Division of Union Carbide and Carbon Corporation, 30 East 42nd Street, New York 17, N. Y. • In Canada: Electro Metallurgical Company of Canada, Limited, Welland, Ontario

Deoxidation Studies Show Advantages of Silicomanganese

Silicomanganese has proved to be highly efficient and economical as a furnace block and deoxidizer, as well as an alloy addition. Steel producers have found that it saves furnace time, produces cleaner steel, and increases the yield of rolled products.

Excellent Blocking Addition

When used as a blocking addition, silicomanganese stops the carbon-oxygen reaction in the open-hearth furnace and permits close control of analysis. The alloy has a ratio of approximately 3.5 manganese to 1 silicon. This proportion will produce a high degree of deoxidation in the furnace.

Why Silicomanganese Is Effective

The carbon boil is arrested more positively by this combination alloy, containing both silicon and manganese, than it is by larger amounts of silicon alone. As a result, close control of the carbon level can be maintained. Also, because of the low carbon content of silicomanganese, the heat may be blocked at a comparatively high carbon level. This saves furnace time, which is critical in reducing costs. Since silicomanganese gets more oxygen out of the bath than silicon alone, the steel is cleaner and has improved surface quality.

Metallurgical Studies Made

Work done by Herty and his associates (1) showed that manganese tends to flux silica inclusions resulting from deoxidation, and permits them to grow in size so that they float out of the bath more rapidly.

More recently, it was found by Hilty and Crafts (2) that manganese and silicon in combination lower the oxygen content much more than silicon alone (see Fig. 1). They also determined that, although manganese by itself is not a strong deoxidizer, it substantially intensifies the deoxidizing power of silicon.

It was shown that in steels with lower silicon contents (below 0.05 per cent), manganese in the amounts usually present as a residual has a strong influence. However, in the silicon range normally used for deoxidation (0.05 to 0.25 per cent), more manganese is required to obtain the full benefit of the combined deoxidizers. For example, at 1600 deg. C, iron with 0.10 per cent silicon and 0.10 per cent or less manganese contains about 0.017 per cent oxygen. With 0.50 per cent manganese, it contains only 0.009 per cent oxygen (see Fig. 1).

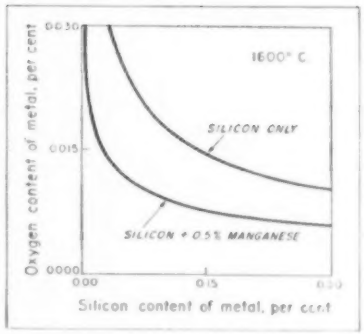

Fig. 1. Limit of solubility of oxygen in iron-silicon alloys, plain and with 0.50 per cent manganese at 1600 deg. Centigrade.

These data thus confirm an observation made by Tenenbaum and Brown (3) that steel as tapped from the furnace is materially lower in oxygen after blocking with silicomanganese.

In another study, made by Silliman and Forsyth (4) it was demonstrated that heavier than usual additions of silicomanganese result in a marked improvement in surface quality. About twice the usual addition of silicomanganese gives a substantial increase in the yield of finished product.

Silicomanganese Produces Cleaner Steel

Initial deoxidation in the furnace with silicomanganese produces very clean steel, particularly in grades below 0.25 per cent carbon. Several factors contribute to the cleansing action of silicomanganese. The amount of dirt in steel seems to be proportional to the maximum oxygen content prior to final deoxidation. Heats that are oxidized to a low carbon and recarburized, as were early rail and forging steels, are dirtier than those in which the carbon is "caught on the way down."

It is also well recognized that medium-manganese and low-carbon steels that are blocked at higher carbon (lower oxygen) contents, with low-carbon ferro-alloys, are cleaner than those taken to a lower carbon level and recarburized with high-carbon ferro alloys. Silicomanganese is low enough in carbon to block at higher carbon levels. As pointed out by Tenenbaum (5), there is also a decided economic advantage in not driving to such low carbon contents before blocking.

Suitable For Ladle Additions

In addition to its use as a bath deoxidizer, silicomanganese has proved particularly effective as a ladle addition for the deoxidation of semi-killed steels. The alloy is also used to provide the complete ladle addition of manganese in the manufacture of medium-manganese, acid-steel castings.

Metallurgical Service Available

Our metallurgists will be glad to help you with the use of ELECTROMET silicomanganese. This alloy contains 65 to 68 per cent manganese, and is produced in maximum 1.50, 2.00, and 3.00 per cent carbon grades. All grades are furnished in a lump size of 75 lb. x 2 in. and in a crushed size of 2 in. x down. If you wish further information, please write, wire, or phone the nearest ELECTROMET office: in Birmingham, Chicago, Cleveland, Detroit, Houston, Los Angeles, New York, Pittsburgh, or San Francisco. In Canada: Welland, Ontario.

References

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3. M. Tenenbaum and C. C. Brown, "The Total Oxygen Content of Plain Carbon Open-hearth Steel During Deoxidation and Teeming," AIME 162, 685-705, 1945.
4. L. R. Silliman and H. F. Forsyth, "Deoxidation vs. Surface Quality," Open-hearth Proceedings, 32, 1949, pp. 218-224.
5. M. Tenenbaum, "The Economic Aspects of Deoxidation," Open-hearth Proceedings, 28, 1945, pp. 349-352.

Correspondence

Tempering of Cyanided Links

TORONTO, CANADA

We recently had occasion to temper some cyanide case hardened parts to a specified Rockwell hardness. Not being able to find any published data to guide us, we did some experiments of our own.

The parts were a machine gun cartridge link 0.064 in. thick, made of S.A.E. 1015. The specifications called for a case of 0.008 to 0.012 in., an oil quench and a draw to Rockwell 76 to 79, on the 15 N scale, which is equivalent to Vickers 319 to 372.

Using a mixture of 30% sodium cyanide and barium chloride in a pot furnace, we kept the hardening furnace temperature constant between 1550 and 1600° F. Lacking a superficial Rockwell, we made a series of hardness tests with a Vickers at a 10-kg. load and a few on the Rockwell A scale. The results were as given in the tabulation below.

It appears from this that sufficient nitrides are present in the steel, even when cyanided at 1550 to 1600° F., to create a great resistance to tempering. A small increase in case depth required a comparatively larger increase in either tempering time or tempering temperature.

Random pieces chosen from any one batch showed a very good uniformity of hardness. The spread was never much more than 15 points on the Vickers scale, being greatest on the untempered parts where the indentation was very small and hard to read.

After heat treating, the parts were put back into a press and straightened. The parts were very difficult to straighten, being very springy. Straightening was best when the warpage was either very large or very small.

While our Rockwell A readings have no actual correlation with Vickers numbers, there did appear to be some evidence that Rockwell A hardness goes down as the Vickers does.

VICTOR EVANS
Manager
Steel Improvement Co., Ltd.

Hardening Temperature	Furnace Time	Tempering Temperature	Furnace Time	Vickers Hardness	Rockwell A Hardness
1575° F.	2 hr.	950° F.	½ hr.	405 to 421	—
1575	2 hr.	1050	1 hr.	390 to 413	—
1575	1½ hr.	950	½ hr.	405 to 427	—
1575	1½ hr.	1050	½ hr.	390 to 413	—
1575	1½ hr.	1050	Double*	383 to 405	—
1575	1½ hr.	1050	1½ hr.	413 to 429	—
1575	1½ hr.	1200	2 hr.	363 to 376	59 to 61
1575	50 min.	1150	½ hr.	312 to 327	55 to 56
1575	50 min.	No draw	—	824 to 847	60 to 62

*First tempering 30 min.; second tempering 1 hr.

Compressive Pattern in a Deposited Titanium Surface

CAMBRIDGE, MASS.

Fig. 1 – Edge of Vapor Deposited Metal

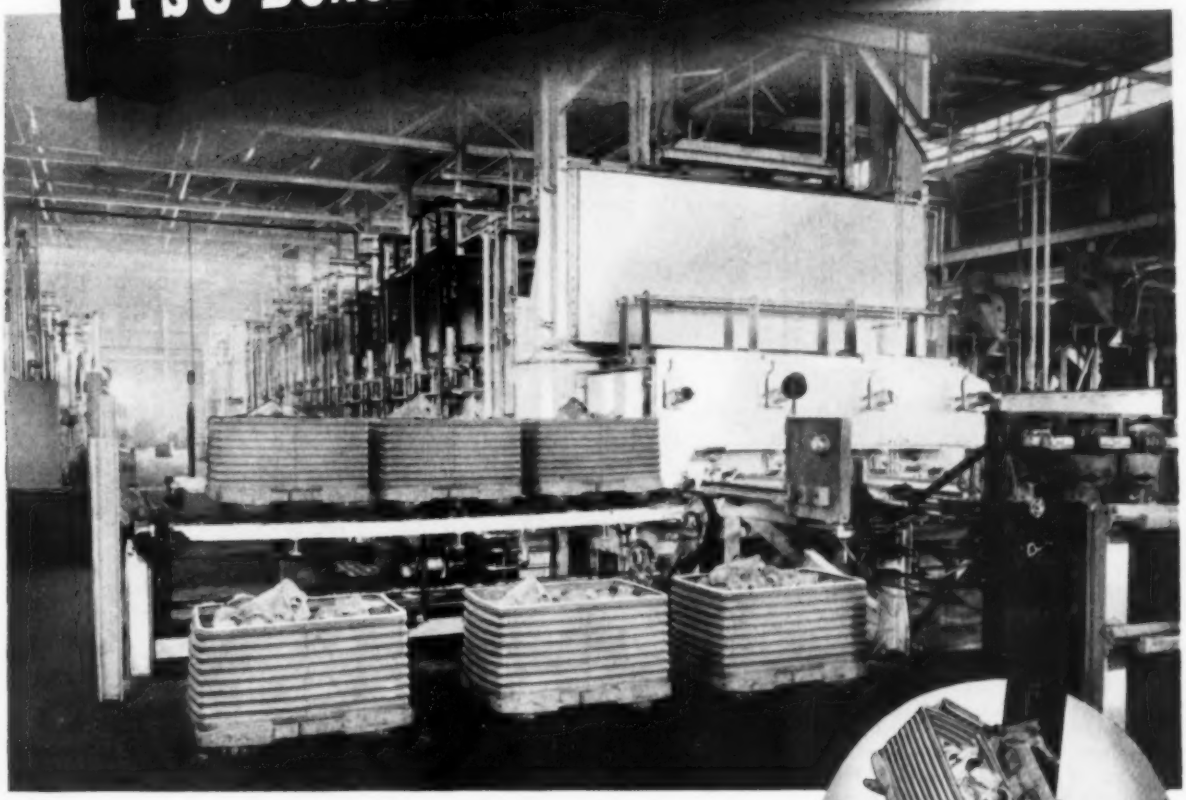
During recent experiments involving the vapor deposition of titanium on glass, the patterns shown in Fig. 1 through 3 were observed.

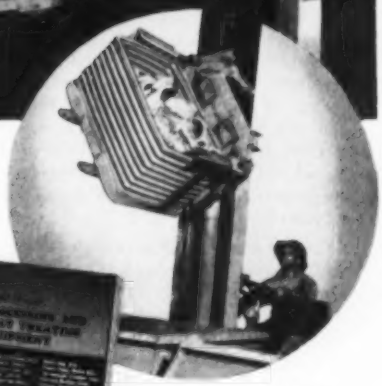
Briefly, the technique of vapor deposition was as follows: A strip of commercially pure titanium was resistance heated in vacuum directly under a piece of plate glass. The method of supporting the glass was such that the titanium deposit was restricted to a circular area.

Immediately after removing the glass from the apparatus, the mirror-like metal surface was smooth and uniformly adherent. However, within

(Continued on p. 116)

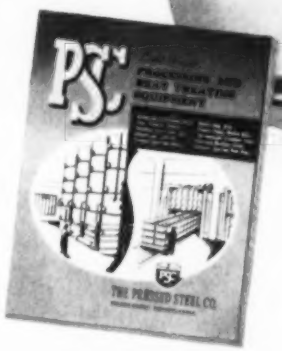
'Albion Malleable Iron' Chooses PSC Boxes for Huge Furnace





PSC Light-Weight Boxes Speed 800-lb. Loads for 120-ft. Long "Surface" Furnace

The above annealing furnace of Albion Malleable Iron Co., Albion, Mich., is one of the longest ever built by Surface Combustion Corp. It's 120 ft. long, and 11½ ft. wide inside. To effect ready flow of work to and from the great furnace, PSC "light weight" boxes were adopted and then designed for use with both roller trays and lift trucks, as pictured. As pioneers of light-weight, sheet alloy, heat-treating containers, we make available to you a wealth of production know-how. PSC furnishes equipment in any size and for any product. Send blue prints or write as to your needs.



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Compressive Pattern in a Deposited Titanium Surface

(Continued from p. 114)

a few hours the periphery of the circular deposit had become dull and flaky. When viewed under the microscope, the dull marginal area had the appearance as shown in the micrographs. Figure 1 shows the edge of the metal deposit and the patterns directed radially toward the center, while Fig. 2 shows the termini of these patterns.

The reason for the disturbed surface is that during cooling after the deposition, the high rate of contraction of the glass with respect to the titanium created compressive forces in the titanium surface. These forces caused a buckling of the titanium away from the glass. The light background in the micrographs is the adherent metal coating.

Figure 3, in which the focus is on the undisturbed metal surface, gives a clearer picture of the structure of the pattern.

FRANK B. CUFF, JR.
Research Assistant
Dept. of Metallurgy
Massachusetts Institute
of Technology

2

3

Co Versus Ti-Stabilized Stainless Steel

HATFIELD, ENGLAND

Further to Mr. Tyrrell's article in *Metal Progress* of July 1950 and subsequent correspondence in the November 1950 issue, investigations just completed here indicate a possible difference between the cobalt and titanium-stabilized stainless steels as regards their resistance to corrosive media.

We customarily employ a special pickle for the removal of surface oxide and borax-type welding flux from oxy-acetylene welded stainless steel pressings, made from material of the order of 0.036 in. thick.

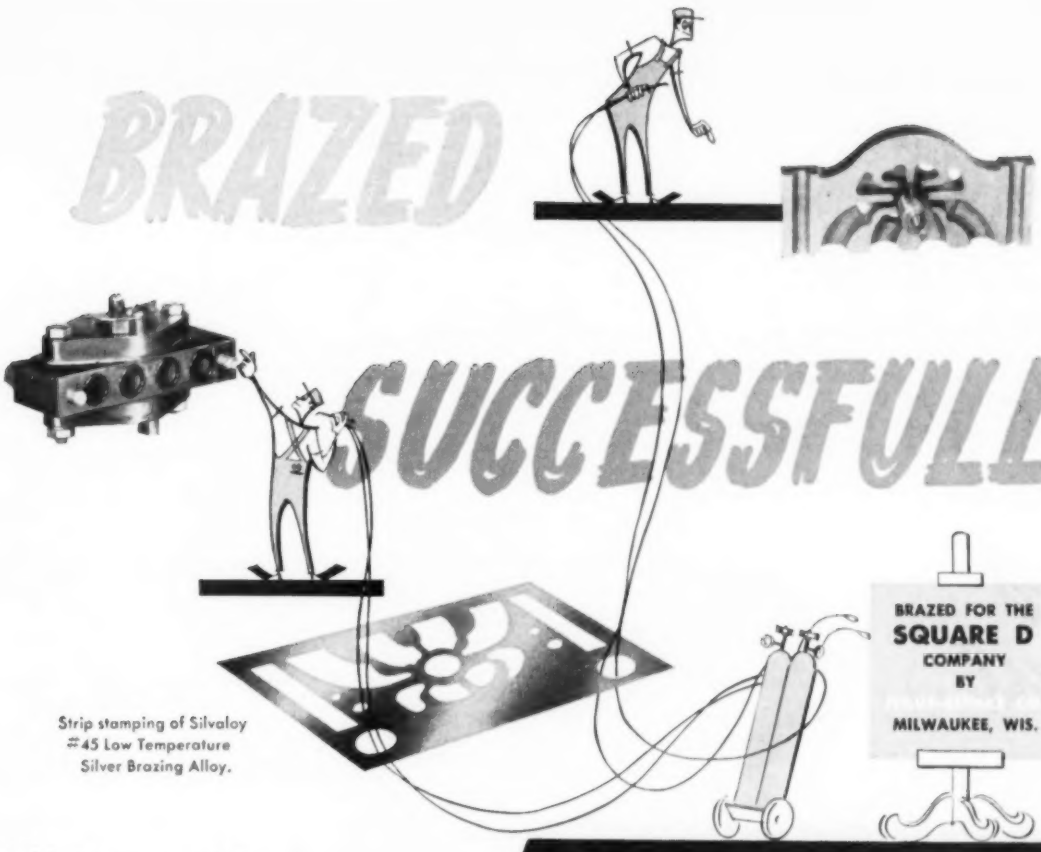
The pickle contains 12% concentrated nitric acid, 3% concentrated hydrochloric acid (both by weight) and a proprietary inhibitor, Hibitite (Monsanto Chemicals, Ltd.), to the extent of 0.35% by weight to the *weight of concentrated acid*. Ordinarily, we treated the parts by immersion for 1 hr. at temperatures between 65 and 75° C. (149 to 167° F.).

The pieces being treated are such things as exhaust manifolds for aircraft engines, and until lately these

(Continued on p. 118)

4

BRAZED SUCCESSFULLY WITH . . .



Strip stamping of Silvaloy #45 Low Temperature Silver Brazing Alloy.

BRAZED FOR THE **SQUARE D** COMPANY BY MILWAUKEE, WIS.

SILVALOY

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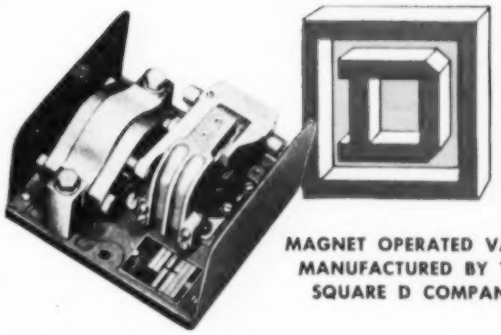
The Magnet Operated Valve manufactured by the Square D Company is an outstanding example of engineering and manufacture. Metal of the precision cast valve body halves, selected for best operating results, is manganese-aluminum bronze . . . a difficult material to braze.

To braze manganese-aluminum bronze on a production basis is a complicated problem. When production brazing must meet Square D standards, it takes the best skill, silver brazing alloy and flux to do the job.

It is being done—successfully—by Nilus-Bethke Co., using Silvaloy #45 Silver Brazing Alloy in strip stampings and APW Aluminum-bronze Flux.

For the best low temperature silver brazing alloys, call the Silvaloy Distributor in your area. They'll also be glad to send Silvaloy Technicians to assist in developing lowest cost —highest production in your brazing department. ★ ★



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Co Versus Ti-Stabilized Stainless Steel

(Continued from p. 116)

have always been manufactured from titanium-stabilized stainless steel. Very recently, we have encountered trouble with violent corrosive attack on pieces immersed in this bath, and subsequent investigation has revealed that the pieces which have been attacked are of columbium-stabilized sheet. (Incidentally, this pickling solution has been contained in a water-jacketed tank made of titanium-stabilized 18-8 stainless. The tank served for approximately 10 years before any repair was necessary and failure was ultimately at the vicinity of the weld.) Figure 4 is a photograph of a duct made of 18-8 stainless which shows selective attack on one half of the duct. The part which is free from attack is titanium-bearing and the part showing pickle attack is of the columbium type.

It is interesting to note that columbium-stabilized material which has been cold worked appears to be the more susceptible to attack in this bath, and this susceptibility is reduced but not eliminated by a heat treatment at about 1900° F.

It may be that this feature is consequential alone on the presence of columbium in the steel, or it may be due to some associated feature resultant from its presence, such as variation in manufacturing process. Unfortunately, it is not possible to readily check our evidence here, as the material generally available is all titanium stabilized. Possibly some would be interested to investigate the matter, as I have no doubt most American materials contain columbium. It may also be that there is some link between these facts and the statement by Mr. N. A. Matthews of the American Brake Shoe Co., to the effect that columbium additions impair oxidation resistance.

Certainly I would be most interested and grateful to have any helpful comments on this subject.

G. W. Weeks
Aircraft Div. Metallurgist
De Havilland Aircraft Co., Ltd.

Shortages Turn Back Clock

Melbourne, Australia

In 1950 and 1951 considerable attention was given in *Metal Progress* to the use of alternatives to columbium for minimizing intergranular corrosion in stainless steels. One aspect which was brought out clearly by the various papers is that tantalum, when used in equivalent proportions (that is, with reference to relative atomic weights), gives almost identical results to columbium in this respect.

Recently, while browsing through some old volumes of *Metal Progress*, I came upon a letter by Professor Edward Maurer published in the May 1937 issue, pages 535-536. Professor Maurer stated that development of the commercial application of 18-8 stainless steels in Germany was held up because Krupp's held the patent right for its production in Germany and had not at that time licensed other manufacturers to make 18-8, although Bohler's had production rights for Austria. Krupp's also held patents covering the use of low-carbon (less than 0.07%) 18-8 and the use of titanium or vanadium to fix the carbon as the carbides.

Professor Maurer further stated:

"Whether these patents will hold is a question, for Bohler Bros. & Co. obtained a prior patent on the use of tantalum, wherein the function of stable carbides was clearly described. Other patents have been issued covering columbium; I understand that the

(Continued on p. 120)

12,000 cubic feet of inert gas fill this furnace to help U. S. STEEL produce cleaner, brighter tin plate

5 Lectrodryers* DRY that gas

Strip is only in this furnace about 105 seconds: 20 seconds in the heating zone, 15 seconds in the holding zone, 15 seconds for slow cooling and then into the rapid cooling zone.

30 tons of tin plate per hour! That's the production pushed through this tower-type annealing furnace at U. S. Steel's Sheet and Tin Mill in Gary. And the strip comes out uniformly annealed, flat, clean and bright.

The DRY protective atmosphere that fills the furnace assures that brightness. Two blowers recirculate this gas, creating considerable turbulence to accelerate heat transfer. Five Lectrodryers keep the gas DRY.

To men having trouble with unwanted moisture in air, gases or organic liquids, Lectrodryer engineers offer their services. Write Pittsburgh Lectrodryer Corporation, 317 32nd Street, Pittsburgh 30, Pennsylvania.

Furnace built by General Electric Company, with the co-operation of Surface Combustion Corporation.

LECTRODRYERS DRY WITH ACTIVATED ALUMINAS

LECTRODRYER

*REGISTERED TRADEMARK U. S. PAT. OFF.

Shortages Turn Back Clock

(Continued from p. 118)

Bohler firm believes that its patent and licensees will not be affected because all ferro-tantalum contains more or less columbium . . ." Its separation was impossible until recently.

"As to the relative advantages of these elements, I quote a communication from Dr. F. Rapatz of the Bohler firm:

" 'I do not believe I exaggerate in naming the following advantages of tantalum over titanium additions:

" '1. Titanium steels are troublesome to work because of their tendency to form a thin scale, likely to be troublesome in the fabrication of sheet.

" '2. General corrosion is increased somewhat by the addition of titanium and tantalum, and the steel impaired in this respect. This is particularly noticeable after cold working. In our experience tantalum makes the steel less sensitive than titanium.

" '3. In welding, particularly electric welding, titanium burns out of the weld metal more easily than tantalum. The welding bead then represents a steel no longer stable against dissociation (weld decay). This is especially troublesome if a second layer is welded over an already existing bead, whereupon susceptible metal underlies the first welded bead. Tantalum is more readily held in the weld metal and this detrimental influence is therefore much reduced.

" 'A disadvantage of tantalum is, of course, that it is more expensive than titanium. I believe, however, that in view of the general high price of the products, especially sheet, this disadvantage is of minor importance.' "

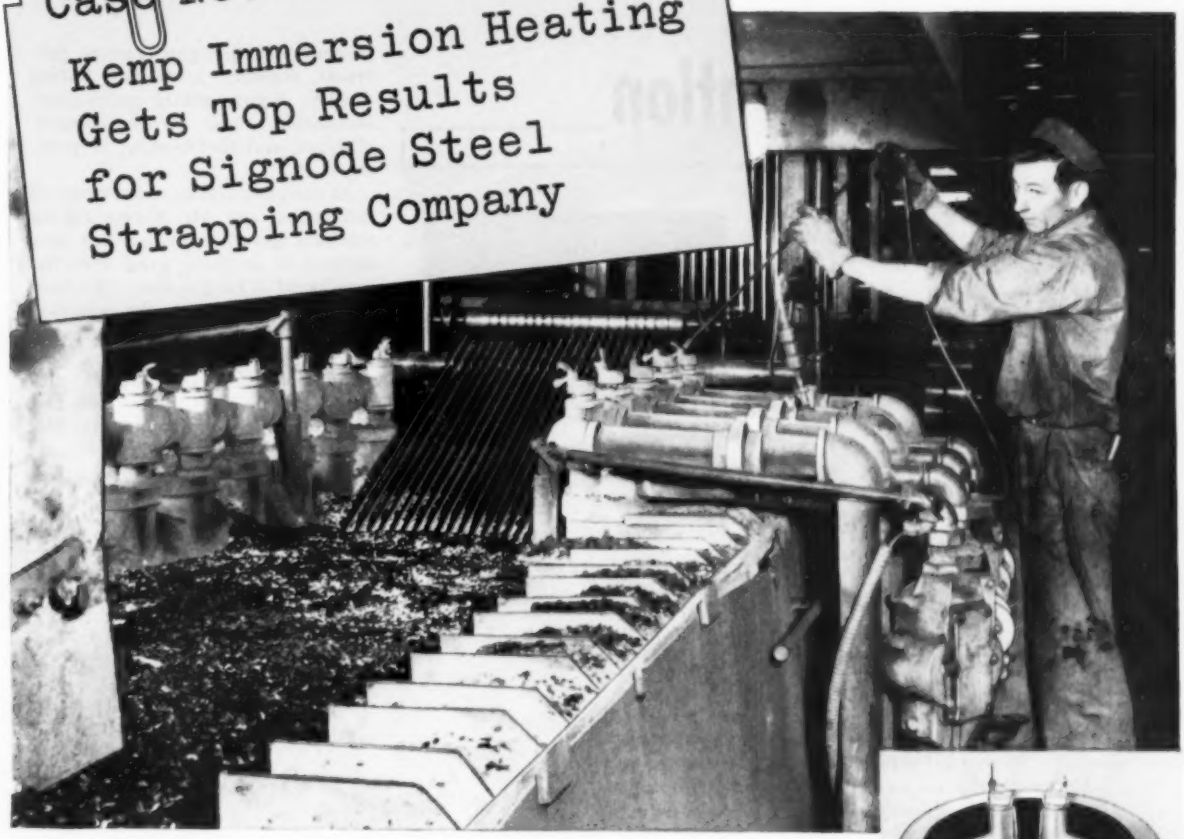
It is interesting to see that tantalum was originally proposed as the stabilizing element for 18-8 stainless steel. Later, presumably, its use was supplanted by columbium which, until recently, was more readily available and also much cheaper than tantalum, both on a cost-per-pound and on a pound-per-ton-of-steel basis.

Nowadays, because columbium is in much greater demand for heat resisting application – applications for which up to the present no completely satisfactory substitute has been found – users of stabilized stainless steels were being forced to use titanium or, in the U. S. A., a proportion of tantalum in lieu of columbium in these steels. This is another instance where, technologically, we are being forced to turn back the clock as a result of shortage of essential materials.

A. L. Simmons
Metallurgical Engineer
Defense Production Planning Branch
Department of Defense Production

Case No. 42

Kemp Immersion Heating Gets Top Results for Signode Steel Strapping Company



How Signode Steel Strapping Co. tempers 650 feet of steel strap every minute

At the Signode plant in Sparrows Point, Md., turning out up to a thousand miles of steel strap daily calls for fast, efficient production line techniques. One highly important phase in the final processing is the tempering bath. Here, Signode called on Kemp Engineers to supply the 15 ton, gas-operated Immersion Melting Pot shown above. Now steel strap is uniformly tempered at the rate of 650 feet per minute.

Kemp Offers More Advantages

By installing Kemp Immersion Heating, Signode benefits in many ways. Unlike underfired pots, Kemp pots are *not* subject to *periodic* and expensive shutdowns . . . won't crack or break. They operate *continuously* at maximum heating efficiency with a ***substantial*** savings in fuel costs. Offer a greater heating surface, faster heat recovery, lower dross formation, even lower room temperatures. At the same time, this Kemp unit enables Signode to eliminate costly temperature override and open flame fire hazards.

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This 10 ton oval pot is typical of the many Kemp installations now in use. Features Kemp Carburetor, part of all Kemp equipment, to deliver complete combustion . . . without waste . . . without tinkering. One-pipe air and fuel feed reduces installation costs, simplifies maintenance.

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Personal Mention

J. Hunter Nead

J. HUNTER NEAD, who for 21 years served Inland Steel Co., Chicago, as manager of the metallurgical and inspection departments, retired recently. During his service he was charged with the responsibility for all metallurgical, chemical and inspectional activities, as well as for research and development and quality control. For the past year and a half he has also served as metallurgical consultant to the president of Inland. Prior to 1931 he was for 12 years chief metallurgist for the American Rolling Mill Co., now the Armco Steel Corp., Middletown, Ohio. This had been preceded by ten years in various metallurgical capacities in the steel industry, and was climaxed by approximately nine months of overseas service during World War I as a captain in the engineering division of the U. S. Army Ordnance Department.

Mr. Nead is one of the pioneer members of , having been a director of the American Society for Steel Treating, predecessor to , in 1927-1928. He is also a member of the American Institute of Mining and Metallurgical Engineers, Society of Automotive Engineers, British Iron and Steel Institute and British Institute of Metals. He has been granted numerous patents and is the author of many technical papers. Mr. Nead is now spending his deserved leisure in the enjoyment of relaxation and avocational interests in his home at Dune Acres overlooking Lake Michigan near Chesterton, Ind.

John O. Almen

JOHN O. ALMEN, General Motors Research Laboratories consultant, terminated a 26-year tour of duty with the Corporation upon his retirement in October 1952. Mr. Almen's engineering career began shortly after he graduated from Washington State College in 1911, when he joined Pullman Motors at Seattle, Wash. From 1915 to 1924, he was chief engineer for Almen Motors, a company organized to produce the wobble-plate engine. In 1924, Mr. Almen went to work at McCook Field, Dayton, Ohio, as an engineer for the government. Here, he continued his work on the wobble-plate engine and also helped to establish a dynamometer laboratory for aircraft engine testing. In 1926 he joined GM Research Laboratories as a research engineer in the power plant section. Later he was named head of the GM research dynamics section, and in 1928 the gear section was placed under his supervision. In 1938 he was named head of the engineering mechanics department, and ten years later he became a consulting engineer, traveling around the country assisting other GM Divisions and outside companies with their technical problems concerned with strength of war materials.

Mr. Almen's research has covered many phases of engineering – both fundamental and applied. His patents cover such widely diversified subjects as hydraulic valve mechanisms, steering arms, lubrication systems, automatic transmissions, suspensions (springing), gears, governors, mufflers, lubrication testing devices, engine testing instruments, automobile radio switch controls, clutches, and shot-blasting or peening tests.

In the more fundamental realm of mechanical arts, Mr. Almen and his research group contributed a new method of designing gears from the standpoint of fatigue life. Effects of this work were seen in the reduction in gear size and increased fatigue life and strength.

In 1946, Mr. Almen's work in prestressing won him the Materials and Methods Achievement Award. The American Gear Manufacturers Association presented him with the Edward P. Connell Award the same year. Other honors he has received include the Manly Memorial Medal, the Army-Navy Certificate of Appreciation, and a citation from the National Association of Manufacturers.

A. H. Roberson , metallurgist with the U. S. Bureau of Mines, Albany, Ore., has been promoted to chief, technical services branch, Region II. He was formerly head, metallography section, physical metallurgy branch. Mr. Roberson is secretary-treasurer of the Oregon Chapter .

Harry R. Dahlberg has been separated from the U. S. Navy as an ordnance specialist and joined the E. W. Bliss Co., Hastings, Mich., as a foundry engineer.

Sydney D. Tannenbaum has resigned his position as manufacturing test engineer at Ford Motor, Aircraft Engine Div., Chicago, to take a position as metallurgist with General Motors Corp., Truck and Coach Div., Pontiac, Mich.

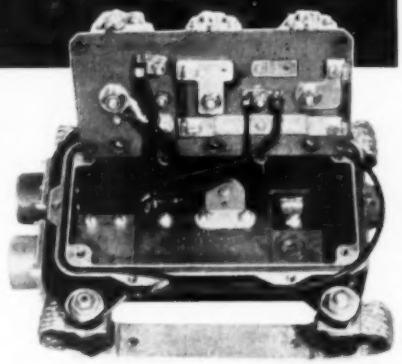
J. L. Unsworth of John A. Roebling's Sons Co. has been elected president of The Steel Club of Philadelphia for 1953, with **Thomas Rutherford** of The Midvale Co., vice-president, and **J. R. McCarron** , of Vanadium-Alloys Steel Co., secretary and treasurer.

Roy Lee Stewart, Jr., is now chief metallurgist, manufacturing division, W. Pat Crow, Inc., Ft. Worth, Texas. He was previously materials engineer for Chance Vought Aircraft, Dallas, Tex.

Wentworth D. Kneller was recently promoted to chief engineer of Kuss Machine Tool Co., Philadelphia.

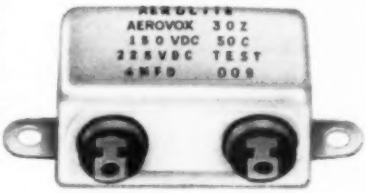
Martin B-61 Matador pilotless bomber taking off. Made by the Glenn L. Martin Company, Baltimore, Md.

Jeep almost completely submerged. Can be operated in this position at about 9 miles per hour. Made by Willys-Overland Motors, Inc., Toledo, Ohio, for the Armed Forces.



Generator regulator for the 24-volt system of the submersible Jeep. This is completely waterproof and highly resistant to corrosion and fungi. Produced by The Electric Auto-Lite Company, Toledo, Ohio.

Illustrated are two of the many types of capacitors and filters made by Aerovox Corporation, New Bedford, Mass.; an important capacitor supplier to both Electric Auto-Lite and Glenn L. Martin. The unit above is the filter capacitor used in the generator regulator of the submersible jeep while the unit at the right is used in the pilotless bomber.



In the Air— On Land— Under Water—

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The dramatic pictures on this page show two important special applications of Aerovox capacitors. One is the Martin B-61 Matador pilotless bomber. It contains an Aerovox capacitor, which has to withstand the terrific acceleration and speed of the craft. The other is the submersible Jeep. Its 24-volt electrical system is completely waterproofed, and includes Aerovox filters and capacitors for suppression of radio interference. Revere not only supplied copper and brass strip for the capacitor cases, but collaborated closely in setting up specifications, and in addition worked on a welding problem. In regard to the latter, an Aerovox Project Engineer wrote: "We have had much better welds." . . . Revere is always glad to collaborate on problems concerning copper and its alloys, aluminum alloys, and electric welded steel tube. Call the nearest Revere Sales Office.

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Personals

Leland F. House has left the research laboratories of Armco Steel Corp., Middletown, Ohio, to accept a position as a technical engineer, materials section, Aircraft Nuclear Propulsion Project, General Electric Co., Lockland, Ohio.

Randolph N. Mitchell, Jr., formerly of Davenport, Iowa, has joined the operating staff of Reynolds Metals Co., McCook, Ill., as rolling mill superintendent.

Leslie C. Hymes, recently graduated from Illinois Institute of Technology, is employed at U. S. Steel, South Works, Chicago, as metallurgical management trainee.

Kenneth J. Sorace has returned to Lamson & Sessions Co., Cleveland, after 18 months active duty with the Air Research & Development Command, Baltimore, Md.

Benny J. Williams has taken a position as metallurgical engineer in the shock strut department, Bendix Products Div., South Bend, Ind.

Van H. Leichliter has been named vice-president of operations of American Steel & Wire Div., U. S. Steel Corp., with offices in Cleveland. First employed by American Steel & Wire in mill metallurgical work in Worcester, Mass., in 1930, he participated, under the direction of J. L. Perry (then district manager), in a systematic investigation of wire mill practices which succeeded in separating the essentials from the traditional. Mr. Leichliter moved to Cleveland as district metallurgist of the Steel & Wire Division in 1934 and was made assistant superintendent of Newburgh Works a year later. In 1939 he was named superintendent of the wire mills at Cuyahoga Works in Cleveland. Two years later he was transferred to Worcester's South Works to become superintendent of the wire mills there, and in 1944 he was made division superintendent, followed by a promotion to general superintendent in 1945. He had been assistant vice-president of operations since 1950.

Charles J. McCarthy, vice-president of United Aircraft Corp., has been elected president of the Institute of the Aeronautical Sciences for 1953. He is a fellow and founder member of the Institute, and has been associated with aviation for over 35 years.

H. E. Cook, superintendent of the Buffalo Works, Aluminum Company of America, for the past ten years, has been promoted to works manager. He began his career with Alcoa in 1930 at the sand foundry, Cleveland Works, progressing to plant superintendent of the Cleveland Magnesium Foundry in 1938.

Russel Heath, formerly metallurgist with Goodyear Aircraft Corp., is now metallurgist, division of industrial research, Washington State College in Pullman.

George W. Orton, formerly chief of the high temperature alloy section, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio, has been transferred to Europe. Capt. Orton's new assignment is executive officer, engineering division, Headquarters, U. S. Air Force.

John L. Ham has been appointed project manager in the metallurgical department of the National Research Corp. He was most recently with Raytheon Mfg. Co., and prior to that with Jones & Laughlin Steel Co. and Climax Molybdenum Co. In his new position, Mr. Ham will be in charge of physical metallurgy in the department.

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Personals

Frederick W. Johnson, formerly assistant chief metallurgist, National Tube Div., Ellwood Works, Ellwood City, Pa., is now superintendent of the metallurgical and inspection departments, National Tube Div., U. S. Steel Co., Fairless Works, Morrisville, Pa.

Gordon C. Pfaff is a metallurgical engineer in the process engineering department, Hughes Aircraft Co., Tucson, Ariz.

Morton Gerla has discontinued his practice as a consulting engineer in Hartford, Conn., and has taken a position with W. L. Maxson Corp., New York.

Melvin L. Bleiberg is now employed by Westinghouse Electric Corp., Atomic Energy Div., Bettis Field, Pittsburgh, as a metallurgist.

John Cutt, formerly metallurgist with Clark Equipment Co., Buchanan, Mich., is now a research metallurgist at Caterpillar Tractor Co., Peoria, Ill.

George B. McMeans has been appointed vice-president in charge of operations for Kaiser Steel Corp. His headquarters will be at the Fontana, Calif., plant, where he has been works manager for the past two and a half years. Although at 39 he is one of the youngest major executives in the industry, Mr. McMeans is a veteran in steelmaking. He began learning the business at the age of 16, working in the Pittsburgh steel mills while attending college. He graduated from Lehigh University in 1935, receiving his degree in metallurgical engineering. He then joined John A. Roebling Sons Co., Trenton, N. J., where he gained rapid promotions and was appointed superintendent of the open hearth and rolling mills division in 1942. In 1947 he joined the Kaiser organization. His responsibilities in his new assignment cover not only the operations of the Kaiser Fontana plant, but also the company's iron ore mine at Eagle Mountain in Riverside County, Calif., and the coking coal mines at Sunnyside, Utah.

R. B. Freeman, formerly assistant to the vice-president for operations, has been appointed project manager for foundry, Columbia-Geneva Steel Div., U. S. Steel Corp., Pittsburg, Calif.

Gilbert Soler, formerly in the research and development department of the U. S. Steel Corp., has joined Universal-Cyclops Steel Corp., Bridgeville, Pa., as assistant technical director. He recently was vice-president, manufacturing operations, Atlas Steels, Ltd., Canada.

Harry L. Jenter has been named assistant district manager of the Cleveland District of American Steel & Wire Div. of U. S. Steel Corp. He was chief engineer of the Wire Division prior to his promotion. Mr. Jenter joined the Division's Trenton Works in 1917 as a draftsman while attending college. Upon graduation from Syracuse University with a degree in mechanical engineering, he was transferred to the Cleveland office as a student apprentice and in 1928 made an assistant foreman at the Cleveland Newburgh Wire Works. He has also been a general foreman, superintendent and more recently chief engineer of the Cuyahoga Works and chief engineer of the whole wire division.

F. P. Strieter, former chief of the casting section of Dow Chemical Co.'s metallurgical laboratories at Midland, Mich., has been named assistant superintendent of the die casting department.

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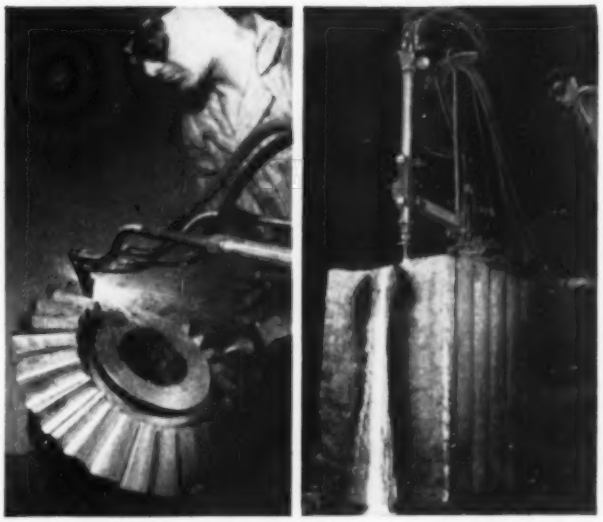
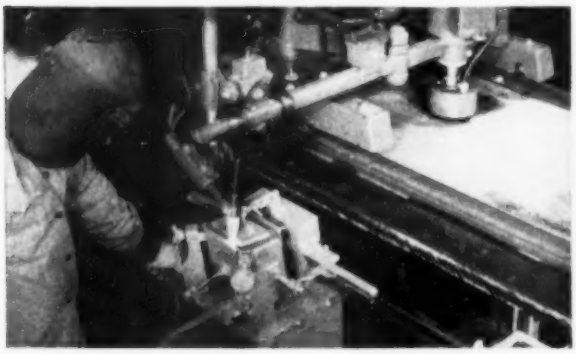


(Left) Flame-hardening gives added service life to parts by providing a hard, wear-resisting surface on a tough, ductile core. (Right) Oxygen-cutting equipment easily slices steel up to 60 in. thick. A 30-in. cut through this 45-in. thick ingot took only 15 minutes.



HELIARC welding in a protective shield of argon or helium gas easily joins hard-to-weld metals such as aluminum, magnesium, stainless steel, and copper alloys. Absence of flux and spatter reduces cleanup and finishing costs.

UNIONMELT welding, a mechanized electric process, joins metals of any thickness without sparks, spatter, smoke, or flash. Welding speeds as much as twenty times greater than by other similarly applicable methods are common.

Powder-scarfing halves conditioning costs on stainless steel. One 8-hr. shift, using two blowpipes, easily powder-scarfs 22 to 24 ingots of 1,000 lb. each.

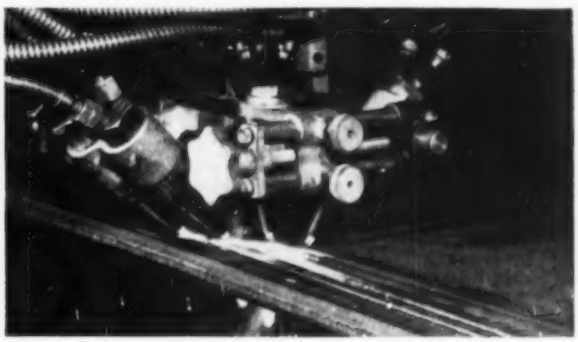


Plate-edge preparation with OXWELD apparatus makes it possible to cut steel plate to size and bevel the edges for welding in one, quick, oxygen-cutting operation.

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Personals

Edmond F. Cook ⊜, special engineer, American Steel Foundries, Alliance Works, has been transferred to their research laboratory in Chicago as research metallurgist.

J. B. English ⊜, chief development metallurgist at Reynolds Metals Co., has been transferred from the Listerhill Operations to Richmond, Va., where he will assume the position of director of the metallurgical research laboratories.

T. D. Radcliffe ⊜, formerly Eastern materials representative for the purchase and stores department, Standard Oil Co. of California, has recently been transferred to Los Angeles as chief materials coordinator, Southern Division.

G. A. Conger ⊜, who taught foundry technology and metallurgy for six years at the University of Michigan, Ann Arbor, accepted a position several months ago as general manager of the Cambria Foundry & Engineering Div., Stevens Mfg. Co., Ebensburg, Pa.

Jerome W. Kaufman ⊜, after recall to extended active duty as a procurement officer in the Ordnance Corps, U. S. Army, was recently released and has returned to his position of metallurgist at the Naval Air Development Center, Johnsville, Pa.

Lloyd E. Raymond ⊜, metallurgist at Singer Mfg. Co., Bridgeport, Conn., was awarded first prize of $1000 in the 1952 "Economy in Production" contest, sponsored by the Tocco Induction Heating Div., Ohio Crankshaft Co., Cleveland. Another ⊜ member, **R. H. Lauderdale**, metallurgist at Northern Ordnance, Inc., Minneapolis, won a $400 prize.

Paul E. Parks ⊜, vice-president and general manager of Industrial Forge & Steel, Inc., Canton, Ohio, a subsidiary of Barium Steel Corp., was elected a director of Industrial. Mr. Parks has been with the company since 1940 in various capacities, including production manager, assistant to the president, and in 1949 was elected to his most recent position of vice-president and general manager.

Ernest A. Schoefer ⊜, formerly executive director of the Alloy Casting Institute, has been elected to serve in the newly created office of executive vice-president of the Institute. Mr. Schoefer has been with the Institute since 1940 when it was formed, and before that with the Alloy Casting Research Institute, predecessor to the ACI. Previously he was a research engineer in the steel industry.

Harold D. Newell ⊜ has been appointed consulting metallurgist and **John J. B. Rutherford** ⊜ chief metallurgist of the Tubular Products Div., Babcock & Wilcox Co., Beaver Falls, Pa. Mr. Newell has been chief metallurgist since 1927, having been with B&W since 1919 and pioneered the development of many alloy tubing steels which have since become widely used in high-temperature high-pressure applications in the petroleum, chemical and general fields. Mr. Rutherford, who has been assistant chief metallurgist, will now be in charge of the research section of the laboratory, process and product development and customer metallurgical service. Prior to his association with B&W in 1938, he was a metallurgist with American Chain & Cable Co. and U. S. Steel Corp.

Joseph Melill ⊜ has accepted employment with North American Aviation, Inc., Los Angeles, materials and process group, as a research engineer. He recently graduated from the University of Illinois.

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Personals

Moss V. Davis, who recently received a Ph.D. degree from Vanderbilt University, has accepted employment at Western Electric Co., Inc., at Winston-Salem, N. C., as a metallurgist.

John C. Pastiran is now a metallurgical engineer in the special products division, Thompson Products, Inc., Cleveland. He graduated from Case Institute of Technology last summer.

Norman N. Breyer was recently appointed director of research and development, National Roll and Foundry Co., Avonmore, Pa. He was formerly chief of armor section, Detroit Arsenal.

Thomas M. Logan has been released from active duty with the armed forces and rejoined Caterpillar Tractor Co., Peoria, Ill., as manager of engineering and cost analysis in the purchasing department. Prior to recall to active duty, he was manager of service development in the service department.

John R. Townsend, well-known engineer with Bell Telephone Laboratories, past-president of the American Society for Testing Materials, and long active in the New York Chapter of the in its formative years, is on leave of absence from Murray Hill Laboratory to serve as director of material and standards engineering of Sandia Corp., Albuquerque, N. M. He will supervise work in physical and electrical laboratories, and organize existing technical information for use in the advanced design of weapons. This work leads directly from his recent activities as consultant to the Director of the Office of Defense Mobilization.

Harry W. Poole has been appointed director of quality control by Superior Tube Co., Norristown, Pa. He was formerly employed by the Brown Instrument Div., Minneapolis-Honeywell Regulator Co., in research and development.

Joseph A. Pfaff, formerly district manager of the New York branch, has been appointed special sales representative for the Latrobe Steel Co., and will continue his headquarters in New York City. **William J. Kennelly** has been appointed district manager of the New York branch succeeding Mr. Pfaff. Mr. Kennelly was previously a sales representative for Latrobe in that territory. **Theodore H. Fortmeier** has been appointed district manager of the newly created Milwaukee branch office. His territory will include most of the state of Wisconsin. Mr. Fortmeier previously handled this territory as a sales representative operating from the Chicago office of Latrobe.

C. K. Lockwood has been elected vice-president of Shawinigan Chemicals Ltd., Montreal. He will be in charge of sales of the stainless steel and alloys division. Mr. Lockwood joined Shawinigan Chemicals in 1937 and became sales manager of the division seven years ago. On part-time loan to the federal Department of Defense Production in 1951 and 1952, he was chief of the stainless steel section of the steel division. In the National Research Council he was a member of the associate committee on high temperature metals in the study of jet alloys.

Charles A. O'Malley has been released from active duty in the U. S. Navy after serving two years in Korean waters, and has returned to Ford Motor Co., Dearborn, Mich., as chemical and metallurgical engineer, quality control, openhearth department.

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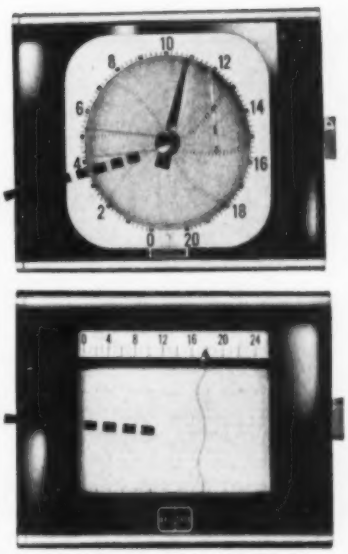

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AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Recovery and Creep*

THE PROCESS of recovery has been assumed to influence creep at elevated temperatures. "Recovery", as used in this report, means a reduction in the amount of strain hardening resulting from exposure to elevated temperatures without changes in the microstructure.

This definition of recovery is restricted since it does not include metallurgical softening processes, such as grain growth and recrystallization. A distinction is made between recovery, which occurs only after straining a metal, and any process that proceeds without prior strain, as overaging or tempering.

Recovery at elevated temperatures has been demonstrated by several investigators, but in most investigations where softening has been attributed to recovery no attempt has been made to demonstrate the absence of a metallographic change. Although it has been widely stated that strain hardening does not occur at elevated temperatures, the experiments in this investigation show that recovery can occur at the temperature of straining.

Tests at 1000° F. were made on a chromium-molybdenum-vanadium alloy steel having a bainitic structure. Pronounced creep occurs at this temperature, but the use of a prior tempering temperature of 1240° F. precludes any tempering during the test. Recrystallization during the test is unlikely because the strain did not exceed 1% and it is assumed that the only softening would be recovery. If recovery occurred during a creep test, the creep-rate after an interruption at zero-stress would be higher than the creep-rate just prior to the interruption.

Even when recovery does not occur, there is a rounding-off of the stress-strain curve which appears to be a temporary softness after a period of zero-stress. This temporary softness is presumably a purely mechanical effect. The length of time at no-load is used to distinguish between the mechanical effect and recovery. A mechanical effect would be independent of time, while the extent of recovery would depend on the duration of the no-load period. Therefore, recovery can be demonstrated by showing that the creep-rate after a no-load interruption is greater than before by an amount that increases with the duration of the no-load period.

The author's tests at 1000° F. show that after an interruption the creep-rate is greater. However, not all of the difference in the rate is due to the recovery. The increase in creep-rate is partly due to the anelastic strain. There is considerable anelastic shortening at zero-stress and it is approximately the same upon reapplication of the load. There was no change in the rate of plastic creep for interruptions of ½ min. For interruptions of 5 to 12 days, the creep-rate is considerably higher immediately after the interruption; within the duration of the tests it does not fall to the rate that would have occurred in the absence of the interruption.

Using the same alloy steel, the behavior at a lower temperature was shown in a test at 800° F. At 800° F., an interruption at zero-stress did not cause a weakening or recovery; it appeared that some strengthening or "strain aging" had occurred. Although recovery influences creep, it obviously does not cause creep because there is pronounced creep at 800° F. where recovery does not take place.

R. E. LOCHEN

*Digest of "Recovery and Creep in an Alloy Steel", by H. A. Lequear and J. D. Lubahn, American Society for Testing Materials Preprint, 1952.

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Chromel, however, is only one of many specialized, quality-controlled alloys developed and produced by Hoskins. Others include: Alloy 502 . . . used throughout industry for a wide range of heat resistant mechanical applications. Spark plug electrode alloys . . . which have become universally accepted standards of quality and durability. Alloy 717 . . . used in facing engine valves for longer life and improved service. And, of course, there are Hoskins Chromel-Alumel thermocouple alloys for industrial furnaces and jet engines . . . unconditionally guaranteed to register true temperature-e.m.f. values within close specified limits.

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Effect of Surface Condition on Chemical Behavior*

THIS PAPER summarizes numerous attempts that have been made to correlate surface roughness with chemical behavior; that is, with corrosion tendency in aqueous media. After reviewing numerous articles, the author concludes that although the surface preparation plays an extremely important role in corrosion behavior, no simple relationships or conclusions are apparent. The preparation of increasingly finer surfaces may conceivably result in increased amounts of distorted metal (Beilby's amorphous layer) on the surface, and hence result in variations not only in apparent surface roughness, but also in the nature of the surface metal itself. This problem becomes complex.

Attempts were made to correlate surface conditions specifically with: *(a)* corrosion tendency, *(b)* distribution of attack, *(c)* velocity of reaction, *(d)* stress corrosion cracking, and *(e)* surface coating. The author recognized that many of the 61 references cited were not sufficiently comprehensive to warrant generalizations and warned against extrapolation of simple laboratory tests to complex industrial conditions. Nevertheless, this mass of data contains a large number of facts which he considers noteworthy.

CORROSION TENDENCY

1. Tests using the "drop method" showed that surfaces prepared with coarsest abrasive papers did not always give the highest corrosion tendency.
2. Artificial scratches on cold rolled nickel usually increased the probability of localized pitting in the scratch to approximately a thousand-fold.
3. Under certain conditions attack was concentrated adjacent to the scratch, whereas the scratch itself was not attacked.
4. Scratches made on metal prior to heat tinting may be more susceptible to attack than scratches made after heat tinting. The reason for this anomaly is not clear.

CORROSION DISTRIBUTION

1. Under conditions where the total corrosive attack is fixed by external conditions, near-perfect surfaces are undesirable because *(a)* rough

(Continued on p. 136)

*Digest of "Chemical Behavior as Influenced by Surface Condition", by U. R. Evans, *Journal* of the Institute of Metals, Symposium on Properties of Metals, 1952, p. 253-280.

This heat-treating container lasted 20 HOURS

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Effect of Surface Condition on Chemical Behavior

(Continued from p. 134)

surfaces are evenly attacked to a moderate depth and *(b)* smooth surfaces are intensely attacked at a few localized areas.

2. Very pure aluminum is known to be considerably more corrosion resistant than commercial grade aluminum, yet was perforated in chromate-chloride solution at a few points presumably at micro scratch-marks on a highly polished surface.

3. Tests with zinc indicated that if geometry permitted particles to settle on corroding surfaces, rough and smooth surfaces would behave in a similar manner.

If the corroding surface is removed, its condition can have no effect on the behavior of the underlying metal, and hence is important on the initial rate of attack.

STRESS-CORROSION CRACKING

In reviewing some well-known principles involved in stress-corrosion and corrosion fatigue, the author emphasizes that:

1. Certain metals are susceptible to stress-corrosion cracking, but all metals are prone to corrosion fatigue.

2. Slip bands, being paths of relatively disordered metal, may be mechanically stronger but are chemically weaker than the unaffected metal.

3. An Al – 7% Mg alloy showed *(a)* greatly improved resistance to stress-corrosion cracking when the surface was buffed, wet alumina-blasted, or polished longitudinally with fine emery, *(b)* slight improvement with shot-peening and *(c)* no improvement was noted with pickling, electropolishing, or polishing with fine emery in the transverse direction.

SURFACE COATING

1. Most coatings are porous and imperfect, hence the nature of the underlying base metal is important.

2. Nonmetallic inclusions, because of their electrical resistance and non-wetting properties, tend to result in pores on electroplated and hot dipped coatings. Thicker coatings may cover these porosities.

3. Nickel and chromium-plated steel specimens show poorer fatigue properties because of the tensional stresses present in the coating.

4. Since sprayed coatings are generally porous only materials anodic to steel (that is, Cd, Mg, Al and Zn) should be used.

There is evidence that corrosion fatigue is improved by peening with increasingly large shot particles, and that subsequent grit blasting is hardly damaging. However, there have been instances where peened surfaces immersed in chloride and carbonate solutions resulted in lower fatigue life than finely ground surfaces. Another reference warned of excessive peening but this research used angular grit rather than round shot.

A. DeS. Brasunas

Wear of Metals*

An argument is presented for the adoption of a new criterion for the wear resistance of a metal which the author calls the "modell" number and is defined as the Brinell hardness multiplied by 10^6 and divided by the elastic modulus. The modell presumably gives an indication of the depth of penetration that a metal can tolerate without undergoing excessive wear. Materials with high modell values generally have good wearing qualities. For example, aluminum oxide has a modell value of 143, chromium plate 83, gray iron 33, and tungsten carbide 22 as compared with 2 for aluminum and 0.7 for tin.

The author considers the elastic limit and the elastic modulus as being the important basic properties which control wear resistance. However, since values for elastic limit are not available for many materials, the author has assumed that the Brinell hardness can be used instead because of the close correlation existing between these two properties.

The modell value of a wear-resisting material can be varied within certain limits by changing its hardness or its modulus. Increasing the hardness does not necessarily result in a more wear resistant material. Tests on a series of gray cast irons having different graphite dispersions showed that wear increased with increasing hardness, while wear decreased with decreasing elastic modulus. In this series, wear decreased with increasing modell values. Data indicate that gray iron should be cast with coarse graphite flakes and hardened by heat treatment to produce maximum modell rather than to obtain high hardness in the as-cast condition.

The general level of the elastic modulus of a metal is determined by its melting temperature and atomic volume. However, the modulus of certain structural materials can be

(Continued on p. 138)

*Digest of "Hardness, Elastic Modulus, Wear of Metals", by T. L. Oberle, *S.A.E. Quarterly Transactions*, Vol. 6, July 1952, p. 511-517.

Wear of Metals

(Continued from p. 137)

markedly altered by changing the microstructure or by mechanical working. For example, the elastic modulus of gray iron can be varied from 8 to 19 million by changing the graphite flake size and volume. Also, the modulus of beryllium-copper can be varied from 14 to 26 million by cold work and heat treatment. Tests on Al_2O_3 cylinder liners showed that they had excellent wear resistance and that the rate of wear of piston rings was greatly reduced.

The importance of foreign abrasive particles in promoting wear was illustrated with the example that many diesel engine parts will run 20,000 hr. when clean air, fuel and oil are used, but will only last about 100 hr. when dirt is introduced. It was shown that the elastic cushion provided by materials of low modell helps to minimize wear only when the grit does not exceed a critical size which is dependent upon the modell, the load and the clearance between surfaces.

E. R. PARKER

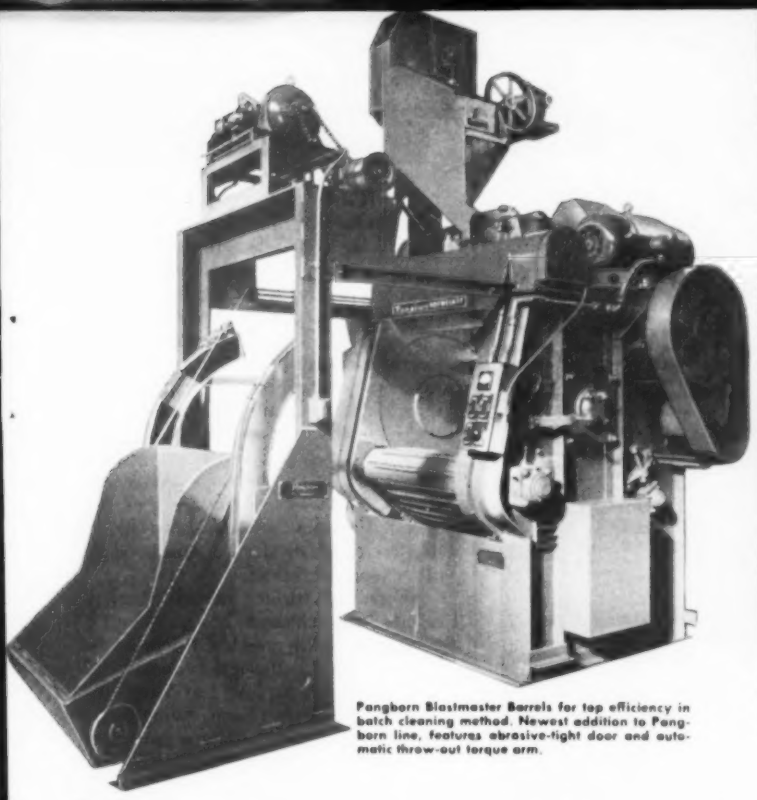
Abraded Surfaces*

WHEN THE SURFACE of a crystal is worked mechanically, as by grinding, polishing, and machining, a marked change in the crystal structure occurs. This disturbed layer is usually about 300 atom layers deep. The authors found that by using both the X-ray and electron diffraction methods, more information was disclosed than when examined only by either method. The additional information disclosed the manner in which the atom layers are disturbed, and the extent of penetration. The electron diffraction method can be used to study the disturbed layers less than a few hundred atoms deep. The X-ray method could therefore yield additional information to a depth of a few microns. The extent of the penetration can be controlled by using the proper X-ray wave length.

In this research the surface structure of abraded calcite crystals was examined by the electron diffraction method. The cleaved surface of the calcite crystals was found to be quite perfect. When the Kikuchi lines of the electron diffraction pattern are sharply defined, it can be inferred that the crystal layers are not disturbed. When these

(Continued on p. 140)

*Digest of "The Crystalline Character of Abraded Surfaces", by P. Gay and P. Hirsch, *Journal* of the Institute of Metals, Symposium on Properties of Metals, 1952, p. 123-132.



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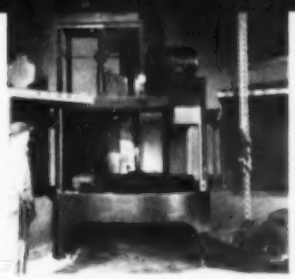

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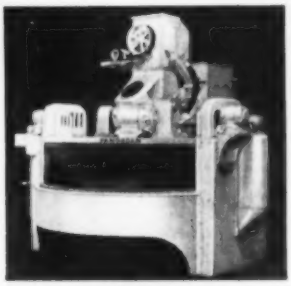

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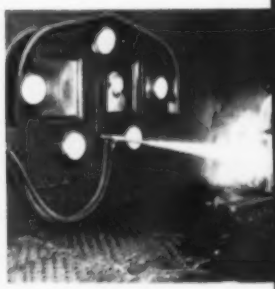

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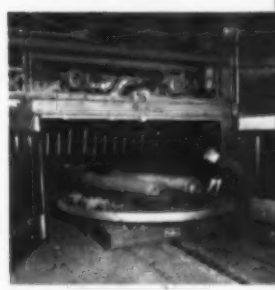

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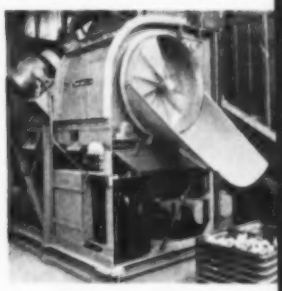

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Abraded Surfaces

(Continued from p. 138)

Kikuchi lines are ill defined, or diffuse, it can be concluded that the atom layers in the surface have become misoriented relative to each other.

It is of interest to note that when the calcite crystal is ground with coarse carborundum, the surface layers are so severely disturbed that only X-ray diffraction methods can be satisfactorily used. Best results are obtained at small diffraction angles. The X-ray diffraction rings are usually continuous, which indicates that the abraded surface now consists of powder-like particles of all orientations, in other words, random.

When the surface of the abraded calcite was cleaned by washing, a good part of the powdered debris was removed; this reduces the intensity of the continuous ring on the X-ray diffraction pattern. Even though the loose debris is removed, one finds that misorientations still remain in the surface. It is indeed surprising to find that the misorientations may be as large as 25° (relative to each other).

The X-ray diffraction rings are continuous and broadened, which is interpreted to mean that the particles (misoriented) are small, less than 2μ.

In view of their work, and others, the authors reached these conclusions about abraded surfaces:

1. A ground surface contains highly misoriented material, the degree of misorientation increasing with increasing abrasion.
2. Small particles are formed during the deformation.
3. Highly polished surfaces exhibit properties of an amorphous layer.
4. The penetration is limited, but depends upon the abrasive used. The distorted layer may be 10μ deep.
5. With increasing abrasion the range of misorientations increases and the particle size decreases. In the extreme the surface may attain an apparent amorphous state.
6. The deformation is one of rotational slip, although there is also evidence of translatory slip and twinning.

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Kinetics of Martensite Transformation*

PREVIOUS STUDIES by Kurdyumov and co-workers had shown that the rate of formation of martensite from austenite has the usual temperature-dependence; that is, the rate increases to some maximum value with decreasing temperature and then decreases again. The present work was a study of the kinetics at higher temperatures to supplement the information previously obtained at temperatures down to that of liquid nitrogen. The investigation was carried out using the thermomagnetic method on a steel containing 0.8% carbon and 2.2% manganese. The martensite point, M_s, of this steel was 155° C. Curves of isothermal transformation of austenite were obtained for temperatures in the range below M_s down to −196° C.

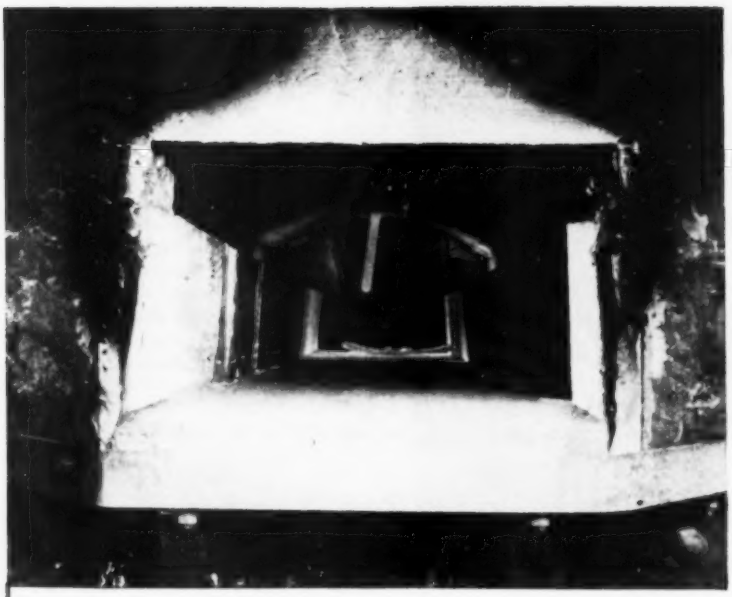
During quenching to the testing (isothermal) temperature, an amount of martensite formed that was larger the lower the temperature. For example, at 118° C. about 12% martensite formed during quenching. An additional amount of martensite formed during holding for an hour or so at the testing temperature; this was about 9% at 118° C. The initial velocity of formation of this additional martensite was the rate studied. The results obtained supported the view that the rate of transformation is slow near M_s, when M_s is significantly above room temperature. Also, the curve of rate versus temperature had a maximum, in this example near 0° C. In fact, between about −40 and 25° C. the rate was immeasurably fast. At lower temperatures the rate decreased and became essentially zero at about −160° C.

These results are significant with regard to the question of the transformation of retained austenite during the room-temperature aging of quenched alloys. If the M_s of a steel lies slightly above room temperature, then appreciable and prolonged transformation of austenite to martensite can occur and cause pronounced changes in mechanical properties.

This investigation has shown that the rate of transformation of austenite to martensite, like other phase changes, is largely determined by two factors: The temperature at which the transformation takes place, and the degree of undercooling. The plot of

(Continued on p. 144)

*Digest of "Kinetics of the Martensite Transformation Above Room Temperature", by G. V. Kurdyumov and O. P. Maksimova, *Doklady Akademii Nauk SSSR*, Vol. 81, 1951, p. 565-568.



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In other words, after 18 months the CARBOFRAX hearth had not only outlasted 3 fireclay hearths, but saved roughly 45 days of downtime. Plus the labor. Plus the materials. Plus the lost production. And, it was still in excellent condition, still helping to deliver an extra 7½ tons of work per week, every week.

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Kinetics of Martensite Transformation

(Continued from p. 142)

rate of transformation versus temperature has a maximum. The location of the maximum velocity and its magnitude are determined by the M_s of the steel or alloy. For high M_s the maximum lies in the vicinity of room temperature and corresponds to an immeasurably high rate of transformation. In this instance there are two intervals of isothermal transformation of austenite to martensite.

A. G. Guy

Uses for Controlled Density Steel Being Studied*

Since the first announcement of controlled density steel by the Ontario Research Foundation about a year ago, development work to determine suitable applications has been proceeding on a cooperative basis between the foundation and interested industrial companies seeking licenses.

By the process, fine iron ore is reduced directly to a desired steel shape without melting or other intermediate steps. The dry, fine ore, usually under 60-mesh, is poured into a suitable porous mold (such as a Croning-type sand shell or porous graphite mold) which is then placed in a metal or ceramic "sagger", in turn filled with a mixture of coke breeze and limestone, and sealed. The loaded container then is heated to 2000° F. and held long enough to produce the desired carbon content and density in the ore.

Density of the finished product is said to be controllable between 1.0 and 7.2 g. per cc. (solid steel is 7.8) and depends upon the swelling or shrinkage characteristics of the iron ore used, on maximum particle size and on particle size distribution. Carbon content may vary from less than 0.01% up to 1.5%.

The reduced rod, bar, or whatever shape may be involved, has the composition and structure of normal steel, except that it contains a predetermined number of spherical voids, not interconnected. This structure is claimed to permit subsequent heating and hot working without any particular precautions for oxidation or scaling.

Hot working of bars by swaging is

(Continued on p. 162)

*Digest of "Controlled Density Steel", *The Engineer*, Dec. 28, 1951, p. 839; also *Canadian Metals*, January 1952, p. 17.

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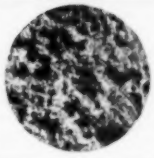	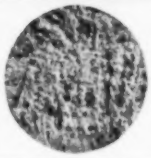

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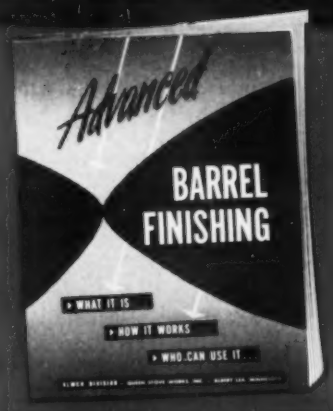

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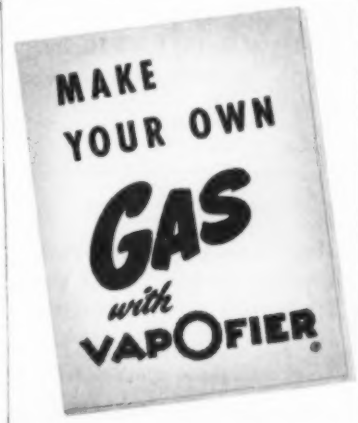

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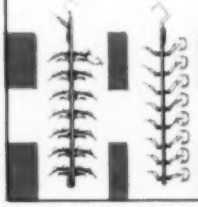

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Hays complete line of draft gages, flow gages and meters (for high and low pressure gases and liquids), portable gas analyzers and automatic CO_2 recorders are covered.

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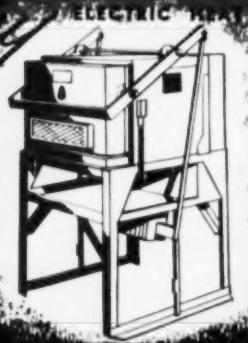

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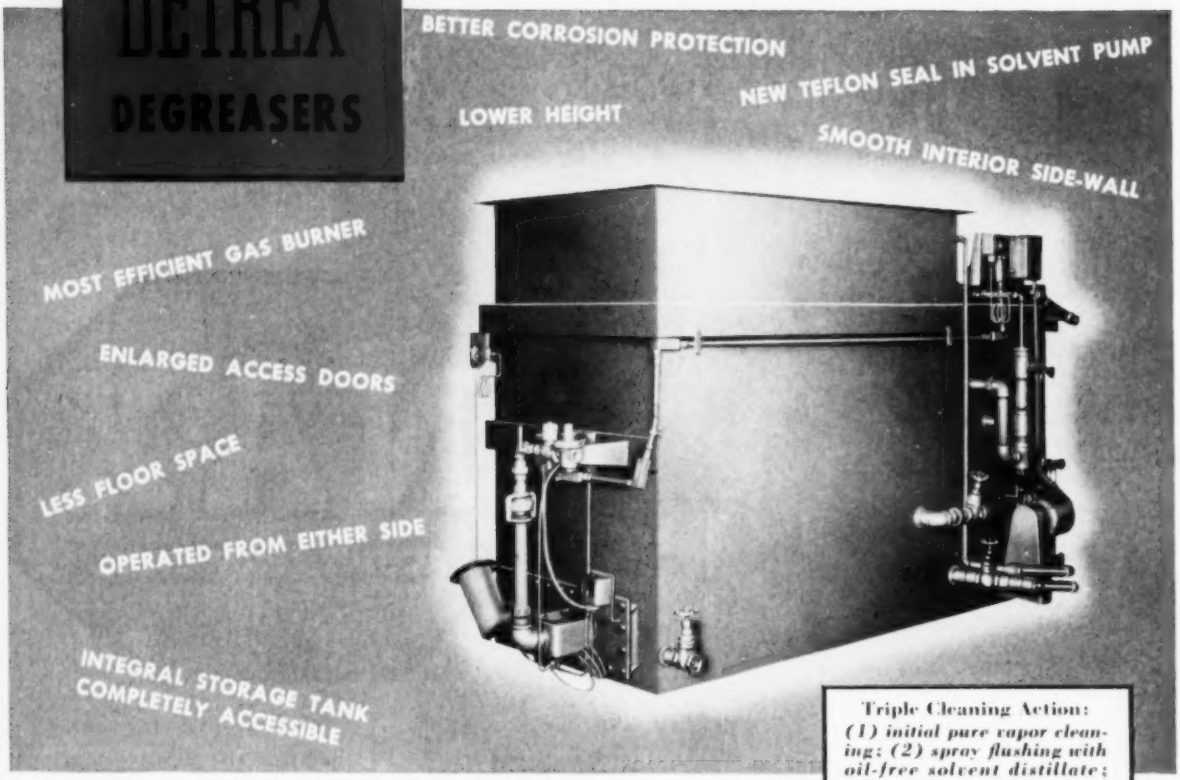

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New atmospheric gas-fired immersion tube heating elements increase heating efficiency 50% (in some cases as much as 100%), save fuel, and permit thermostatic control of the heating tube. (VS 800 degreasers also are quickly adaptable for electric or steam heating.)

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If, like Tar Baby, the metalworking industry sat still and said nothing, little could be learned of its original-metal needs and demands. Scant progress in original-metal production would be the result.

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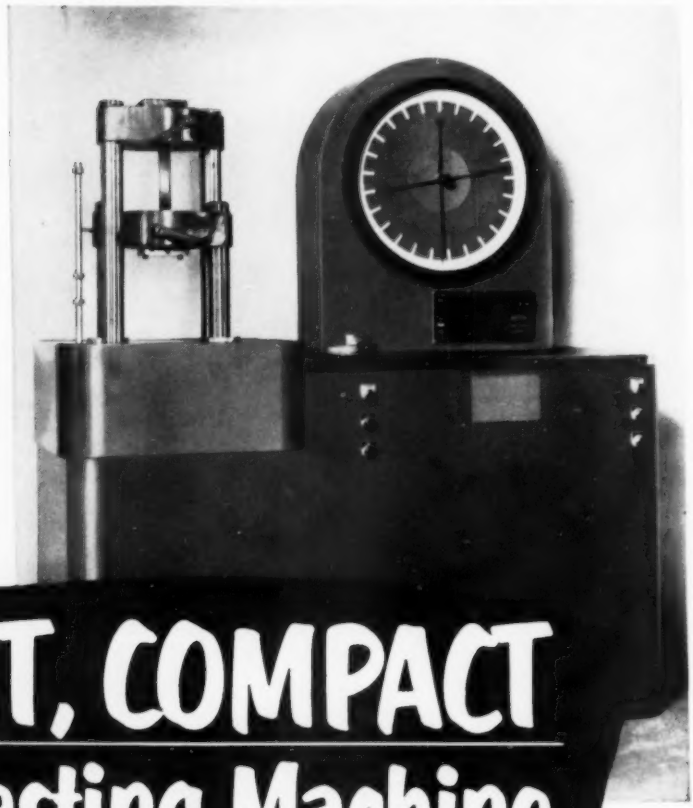
Universal Testing Machine Model 60-H with T.E.G. load indicator



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LOW COST, COMPACT Universal Testing Machine

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With one of these new machines you would gain all of these advantages: (1) The first low cost machine which exceeds all minimum requirements for the routine testing job. (2) Faster, more rugged, more foolproof and able to stand more abuse than any comparable machine. (3) Operational damage prevented by simple safety devices. (4) One unit design with two unit features . . . will fit area only 67½" by 27"! Indicator housing supported independently to eliminate transmission of recoil. (5) Adjusting screws are completely enclosed in base and lubricated for life, eliminating worry and care. (6) Practically noiseless operation. Single knob control for loading and return.

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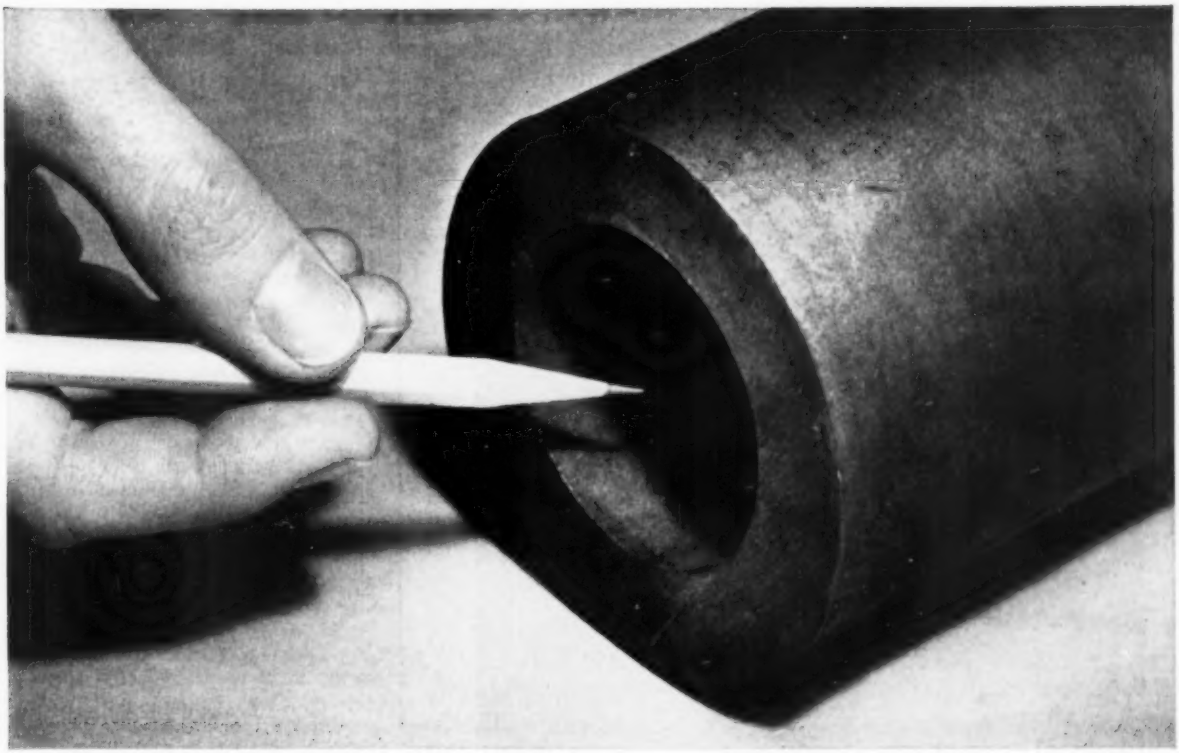

If you make hollow parts, here's where you can save steel and machining time

THE hole is already there when you use Timken® seamless tubing. Often, you can go right into finish boring as your first production step. You save machining time. Screw machine stations can be released for other operations. You get added machine capacity without additional machines.

By using Timken seamless tubing in place of bar stock, you save steel, too. Scrap loss is cut. You get more parts per ton of steel. And to help you save even *more* steel, the Timken Company offers a tube engineering service which recommends the most economical tube size for your job—guaranteed to clean up to your finished dimensions.

Timken seamless tubing gives you high internal quality because the piercing process by which it is made is basically a forging operation. Result: a uniform spiral grain flow for greater strength and a refined grain structure which brings out the best quality of the metal. And the Timken Company's rigid control keeps this quality uniform from tube to tube and heat to heat. The Timken Roller Bearing Company, Steel and Tube Division, Canton 6, Ohio. Cable address: "TIMROSCO".

YEARS AHEAD—THROUGH EXPERIENCE AND RESEARCH

SPECIALISTS IN FINE ALLOY STEELS, GRAPHITIC TOOL STEELS AND SEAMLESS TUBING

Uses for Controlled Density Steel

(Continued from p. 144)

practical. When reduced in cross sectional area by more than 80%, tensile properties, elongation, reduction of area and hardness correspond closely to those of conventional steel of the same composition and in the same stage of processing. Further cold working may be done in the regular manner. Hot working and forging of other shapes is feasible as long as the part is totally enclosed on at least four sides. The first working must be extremely light, but once a density of 7.5 has been reached, usual methods and pressures are acceptable.

Cost of the high density product is out of line by a considerable margin with ordinary steel, so scant possibility is seen of any competition on a tonnage basis. Material in the density range of 4.0-6.5 shows mechanical properties and composition comparable to those of pressed and sintered iron powder compacts. Here the process is envisaged as in direct competition with powder metallurgy techniques. Tolerances, however, are not of the order achieved in pressed powders, being more in the range of castings. In this application, costs of the controlled density steel should be lower where dimensional tolerances are not strict.

A third class of products in the density range between 1.0 and 4.0 has been given the name "light steel". While tensile strength, ductility and impact are low, properties do compare with those of wood, suggesting competitive possibilities with parts and shapes of plastics, wood and, in some cases, aluminum or magnesium. This light steel will not warp or split and can be soldered, welded, painted, plated or porcelain enameled. Shaping is easily done with ordinary woodworking tools.

Laboratory work on the reduction process began in May 1951, and it has now moved to the pilot-plant stage with parts being produced in a 65-ft. electrically heated tunnel kiln. Accurate data on production rates and costs are being sought.

Engineers of the Ontario Research Foundation believe the process will find its place as a supplementary technique for production of many useful steel articles. When parts are used directly from the furnace, without further working, iron ores containing large amounts of impurities are adaptable. Since the metal never passes through a liquid stage, it is necessary only to keep impurities such as silica down to an acceptable level.

This rocker arm is used in refrigerator temperature control units. It is made of C 1010 steel, liquid carburized in AEROCARB E&W at 1600°F and oil quenched. Case depth: 0.005 inches. Hardness: 80 Rockwell 15N.

This swivel pin for oscillating fans, made of C 1117 steel, is also carburized in AEROCARB E&W at 1600°F and oil quenched. Case depth: 0.020 inches. Hardness: 80 Rockwell A.

How WESTINGHOUSE cuts costs with AEROCARB® E&W salt baths!

Many of the parts for such household appliances as refrigerators and electric fans are liquid carburized in AEROCARB E&W salt baths at Westinghouse Electric Corporation's Springfield, Massachusetts, plant.

Westinghouse has found their AEROCARB E&W salt baths extremely economical to operate. Manufacturing costs have been cut by the low distortion obtained on parts treated in AEROCARB E&W, as well as by the ease with which salt is removed after the oil quench. In addition, the parts have excellent wear resistance.

Some parts are zinc plated, but require no special surface preparation prior to plating because of the bright, clean surfaces obtained in AEROCARB E&W salt baths.

Get the complete story on AEROCARB E&W liquid carburizing compounds – they may be the answer to your parts problems.

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Role of Metals in Telephone Cable Sheaths*

THE 300,000 MILES of cable sheath used in the Bell Telephone System provide a first line of defense for the system's 70,000,000 circuit-miles against the whims of nature and man. This sheath must meet definite requirements, both in handling prior to installation and under environmental conditions. The latter may be classed as mechanical, electrical and corrosional. Mechanical includes tensile strength, resistance to abrasion, creep, bruising and fatigue caused by vibration and temperature change. Electrical requirements are necessitated by lightning and the inductive interference effects of power lines, while corrosion demands result from stray currents from electrical railway lines, earth currents or from corrosive soil and duct conditions.

There are four basic sheath designs. The simplest is plain lead extruded over the cable core. About 1% antimony is alloyed with the lead for better fatigue properties. This type of sheath is easily spliced by hot wiping a lead sleeve directly to it.

"Alpeth" and "Stalpeth" sheaths are more recent designs. The former consists of an 0.008-in. aluminum tape applied longitudinally with overlap and an extruded polyethylene outer jacket. Seam in the aluminum is filled with a polyisobutylene cement, and a flooding of thermoplastic cement is applied over the aluminum to form a bond with the outer jacket. The sheath is a postwar development, occasioned by shortage and high price of lead. Splicing requires the cementing of plastic sleeve over the joint.

An early difficulty with the Alpeth sheath was cracking of the outer jacket from the action of contaminants, including soap and detergents. However, this trouble has now been greatly reduced, mainly through increasing the average molecular weight of the polymer.

Modification of the Alpeth sheath came in the form of the Stalpeth design in which a corrugated 0.008-in. aluminum tape is applied longi-

(Continued on p. 166)

*Digest of "Bell System Cable Sheath Problems and Designs", by F. W. Horn and R. B. Ramsey, presented before the American Institute of Electrical Engineers in Cleveland, Oct. 24, 1951; published in *Transactions* of the A.I.E.E., Vol. 70, p. 1811-16; also as Monograph 1917 in Technical Publications of the Bell Telephone System.

Role of Metals in Telephone Cable Sheaths

(Continued from p. 164)

tudinally with a slight gap. There is then a corrugated 0.005-in. terne-coated steel tape applied longitudinally with a soldered overlap. The steel is flooded with thermoplastic cement and over this is applied a polyethylene jacket.

Soldering is the critical step in manufacturing. A flat solder strip is fed into the overlap in the corrugated steel just after forming, and the cable immediately passes under the work coil of an induction heater. Soldering is accomplished at 4 to 5 kva. and with a line speed of 50 ft. per min. Stalpeth eventually will replace Alpeth, initial cost being about the same and splicing costs lower because of the steel jacket.

A basic sheath design for lightning protection is known as "Lepeth", comprising a 75-mil layer of polyethylene surrounded by a layer of lead. A flooding of thermoplastic cement is applied between the polyethylene and lead layers.

Several types of wrappings may occasionally be used over the basic cable sheaths, principally the plain lead and Lepeth types. They include jute, steel tape armoring, light wire armoring, and single and double wire armoring.

A. H. ALLEN

Cause of Work Hardening*

IT IS GENERALLY ACCEPTED by students of the solid state that metallic crystals are not flawless, but in their normal state contain two types of imperfections. One type is vacant lattice sites, which may have originated by evaporation of atoms from hot surfaces and the migration of such vacancies inward into the body of the crystal, or the replacement of evaporated atoms by atoms immediately below – which amounts to the same thing. "Self-diffusion", and diffusion of substitute atoms occur through these vacancies, and the vacancies themselves can move and more can be created above temperatures T_m which vary with the metal, ranging from about 600° F. for aluminum, 1500° F. for iron and 1800° F. for platinum. *(Continued on p. 168)*

*Digest of the lecture "Mechanism of Work Hardening of Metals", by N. F. Mott before British Institution of Mechanical Engineers, published in *The Engineer*, Vol. 194, Nov. 21, 1952, p. 694.

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● Singer Manufacturing Co., makers of famous Singer Sewing Machines, reports the following results when they switched to TOCCO—hardening the shaft assemblies shown above. Note the operations eliminated through the use of TOCCO and the savings of 151.8 minutes per 100 parts.

OLD METHOD		TOCCO METHOD	
Operation	Min./100 Pcs.	Operation	Min./100 Pcs.
Assemble on plating racks	23.0	eliminated	
Copper plate crank end	43.0	eliminated	
Remove from plating racks	15.0	eliminated	
Harden shaft and anneal crank	120.0	TOCCO harden and clean	92.5
Strip lead	10.0	eliminated	
Strip copper and clean	33.3	eliminated	—
Old method total time	244.3 minutes	TOCCO method total time	92.5 minutes

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Cause of Work Hardening

(Continued from p. 166)

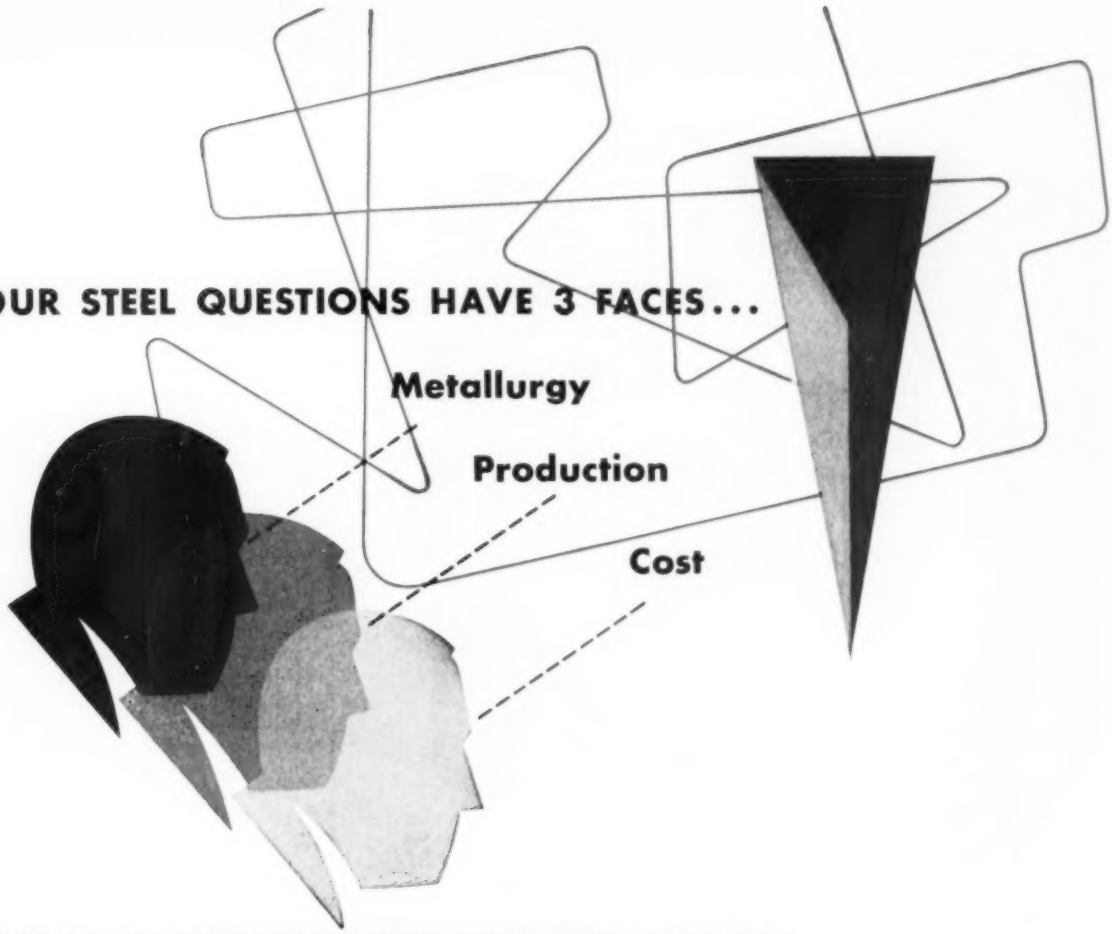
Cold working is believed to increase the number of such vacant lattice sites, and while these can move about in the crystal at temperatures below T_m and self-diffusion may also be enhanced in proportion to the number of vacancies, no new ones are created below T_m. At low temperatures, roughly halfway from T_m to absolute zero, the vacancies became frozen in position.

The second type of irregularity in the metallic crystal consists of "dislocations" and slip bands. A dislocation is the area *within* a crystal (it does not need to extend to a grain boundary) wherein adjoining portions have slipped through only one atomic distance. Slip bands represent almost instantaneous movements up to 1000 times as great and over an area on the order of 1 sq.mm. – although here again they do not need to end in grain boundaries; an intracrystalline terminus is at a dislocation, as defined above. Plastic deformation at ordinary temperatures consists of the formation of a succession of such slip bands. The region in the neighborhood of a slip is particularly likely to slip again.

A theory explaining cold deformation and work hardening must explain why slip occurs at low stress and on selected planes closely adjacent to each other. It would depend on the accepted fact that a multitude of dislocations occur in metal crystals, even when annealed. There are perhaps 10^{12} of these per cu.cm. and they act as sources from which slip can start and spread. Mathematical analysis indicates that the required stress is on the same order as the yield point of single crystals of the given metal, even though the bulk of the lattice is of much higher theoretical strength.

Once such a slip starts it will spread rapidly over the whole crystalline plane to its boundaries unless something stops it. A dislocation of high strength must appear at ends of those slip planes which terminate within the body of the crystal. In fact the hypothesis is proposed that once slip has been initiated at some source, the lateral growth of the slip band generates strained regions until the internal stresses induced in those strained regions are big enough to stop further movement along the slip band. This is one type of obstacle beyond which slip cannot extend. A grain boundary is obviously another such obstacle. Another type of obstacle would be created where slips along two different families of planes

(Continued on p. 170)



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WRITE FOR this booklet of case histories on "Republic Alloy Steels, and How to Get the Most Out of Them."

LOOKS AT ALL THREE—Whatever you make . . . or plan to make . . . these 3 questions dictate your decision on steel grades. When leading fabricators, small or large, have any question about the right answer, they call in a Republic Field Metallurgist. They know that his final recommendations on alloys, machining, and heat-treating procedures will include the opinions of the other two members of the Republic 3-Dimension Metallurgical Service team . . . a Mill Metallurgist and a Laboratory Metallurgist.

Your metallurgist and production manager may be stumped by a steel problem. Or may want confirmation of steel grades or heat treatment. Ask your Republic salesman to call in Republic's 3-Dimension Metallurgical Service. It is yours to use.

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Other Republic Products include Carbon and Stainless Steels—Sheets, Strip, Plates, Pipe, Bars, Wire, Pig Iron, Bolts and Nuts, Tubing

Cause of Work Hardening

(*Continued from p. 168*)

intersect – this is a "sessile" dislocation which cannot move. If sessile dislocations are granted, they can explain two important facts, namely that plastic flow is not reversible, and that highly strained regions do not act elastically (move when external stress is removed).

If slip spreads clear across a sample consisting of a single crystal, little hardening occurs. In ordinary polycrystalline metal if slip is stopped by a grain boundary or a sessile dislocation, an intense center of internal strain is formed, locked in position. The random strains so formed within the metal are directly responsible for work hardening.

Since dislocations responsible for work hardening are associated with such large irregularities in crystalline architecture as to be equivalent to vacancies, as defined in the first paragraph of this digest, softening by heating below recrystallization temperatures should occur when these vacancies can move into regions where lower stress will result. The required temperatures should correspond to the range of temperatures wherein self-diffusion is possible and they do.

Hardness of a work hardened material is due to groups of dislocations of definite type and association. Softening will occur if these dislocations separate from each other. This they can do through the movement of vacancies. Therefore softening can occur when self-diffusion is possible.

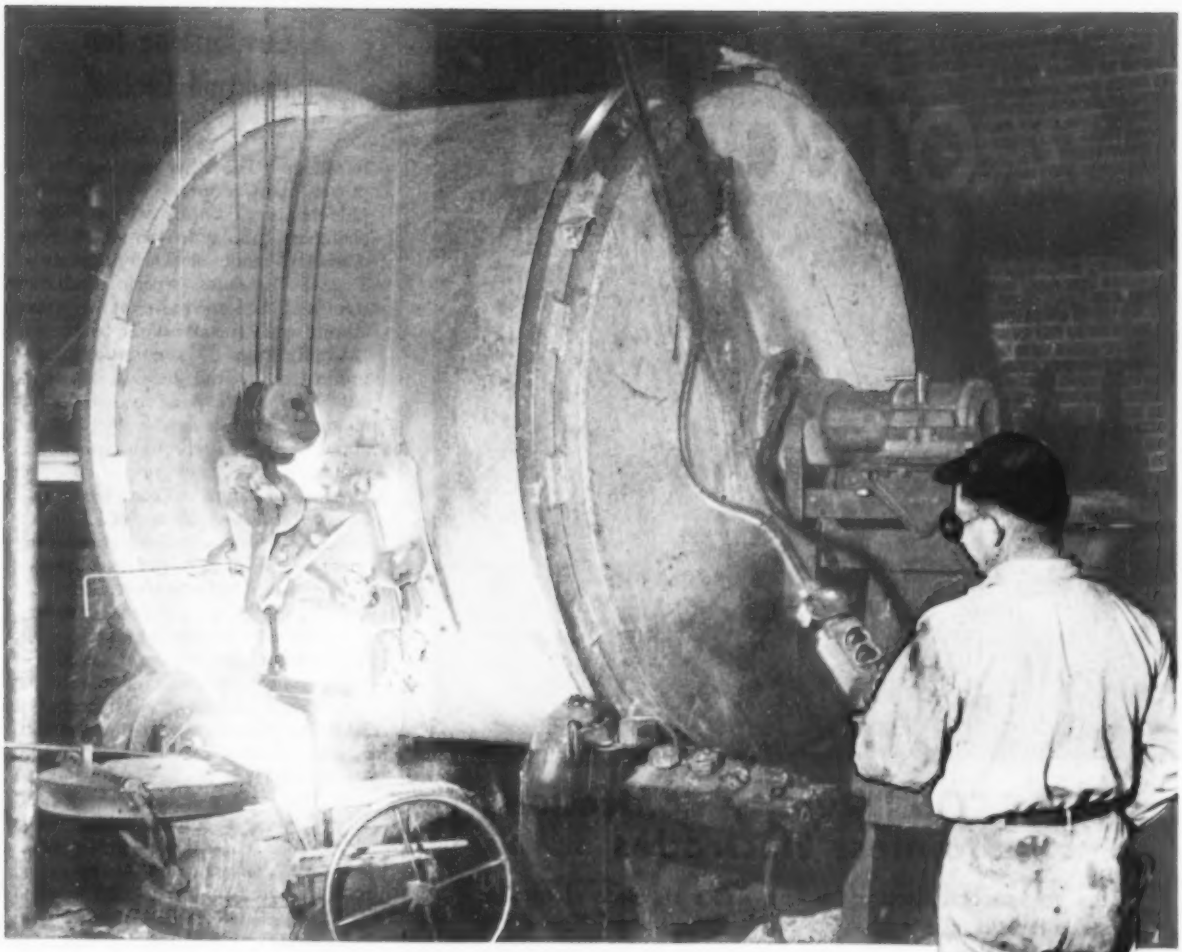
E. E. T.

Gas Turbine for Railroad Engine*

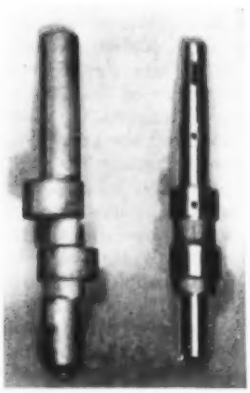
AN EXPERIMENTAL gas turbine power plant for a turbo-electric railroad locomotive, using powdered coal for fuel, has been under successful test at Dunkirk, N. Y., by the Locomotive Development Committee of Bituminous Coal Research, Inc. The turbine, built by Allis-Chalmers, is designed to produce 14,000 hp., of which 9750 is required for the 21-stage axial flow air compressor, leaving 4250 hp. for delivery to the electric generators. One of the 50-ft. dummy cars contains coal bin, coal dryer and pulverizer, although it appears likely that it will be more economical and satisfactory to pulverize the coal in stationary plants and load it into the tender at division

(*Continued on p. 172*)

*Digest of "A Coal-Burning Gas Turbine", *The Engineer*, Nov. 14, 1952, p. 643.



This furnace helps make ice cubes and cool breezes



Raw casting and finished crankshaft of York hermetic compressor. Cast from metal melted in Detroit furnace.

TWO Detroit Rocking Electric Furnaces produce the iron alloys for castings used by York Corporation in their ice-making and air conditioning equipment. The furnace illustrated has an 8000 lb. capacity; the other's capacity is 2000 lbs.

In the York foundry, Detroit Rocking Electric Furnaces were chosen to meet the requirements for high quality heats produced with speed and economy. Rocking action of the furnaces makes full use of heat from the indirect arc, and guarantees a homogeneous melt. Better metal means better castings, fewer rejects, lower cost.

Investigate Detroit Rocking Electric Furnaces for your needs. For ferrous and nonferrous metals. Capacities from 10 to 8000 lbs. Each installation is engineered to fit *your* particular requirement, solve *your* problem.

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Foreign Representatives: in BRAZIL—Equipamentos Industrias, "Eisa" Ltd., Sau Paulo; CHILE, ARGENTINA, PERU and VENEZUELA: M. Castellvi Inc., 150 Broadway, New York 7, N. Y.; MEXICO: Cia Proveedora de Industrias, Atenas 32-13, Apartado 27A3, Mexico 6, D. F., Mexico: EUROPE, ENGLAND: Birlec, Ltd., Birmingham.

Gas Turbine for Railroad Engine

(Continued from p. 170)

terminals. The other car contains the power plant proper. The stream of pulverized coal enters two combustion chambers tubular in shape, 30 in. in diameter, made of 3/16-in. plate of Type 347 stainless steels. Radiation shields of the same material are placed around each Inconel flame tube.

Combustion is in compressed air, preheated by the exhaust gases to 420° F. Gases leaving the combustion chamber enter a fly-ash separator at about 1300° F., through Inconel X piping.

Ash separation is complete; none has collected on turbine blades during 178 hr. of test operation – blades are entirely free of deposits and erosion.

Gases enter the six-stage turbine at 1050 to 1100° F. Materials of construction are: Forged rotor of 16-25-6; fixed blades are investment castings of S-590; rotor blades are machined S-590 forgings; casing is fabricated of 19-9 DL. Gases exhaust at about 550° F. into a heat interchanger, giving up some of its heat to the combustion air and going to the stack at about 380° F. The cycle efficiency rises from about 18% when the electric generators are delivering 2000 hp., and reaches a maximum of 22.7% when 3120 hp. is delivered. At maximum load (4250 hp.) the cycle efficiency is about 20%. About 4000 lb. of coal per hr. are burned when the generators are delivering 4000 hp.

E. E. T.

Metal Conservation*

THIS REPORT gives a concise summary of the metal supply situation in the United States and the United Kingdom at the close of July 1951. The availability of some forty industrial metals is reviewed, the possibility of increased production is discussed, and plausible substitutes for critically scarce materials are considered.

With the exception of iron and steel, all of the other metals are available either in very short supply or in fair supply. In July 1951, the situation with respect to aluminum, cobalt, copper, lead, magnesium, molybdenum, nickel, columbium, platinum, rhodium, silver, tantalum, tin, tungsten, and zinc was quite critical in both countries. Antimony, bismuth, cadmium, chro-

*Digest of "Saving Scarce Materials", Anglo-American Council on Productivity, November 1952, distributed by Mutual Security Agency, 2 Park Avenue, New York 16, N. Y.

mium, germanium, silicon, tellurium, and vanadium were in very tight supply at that time.

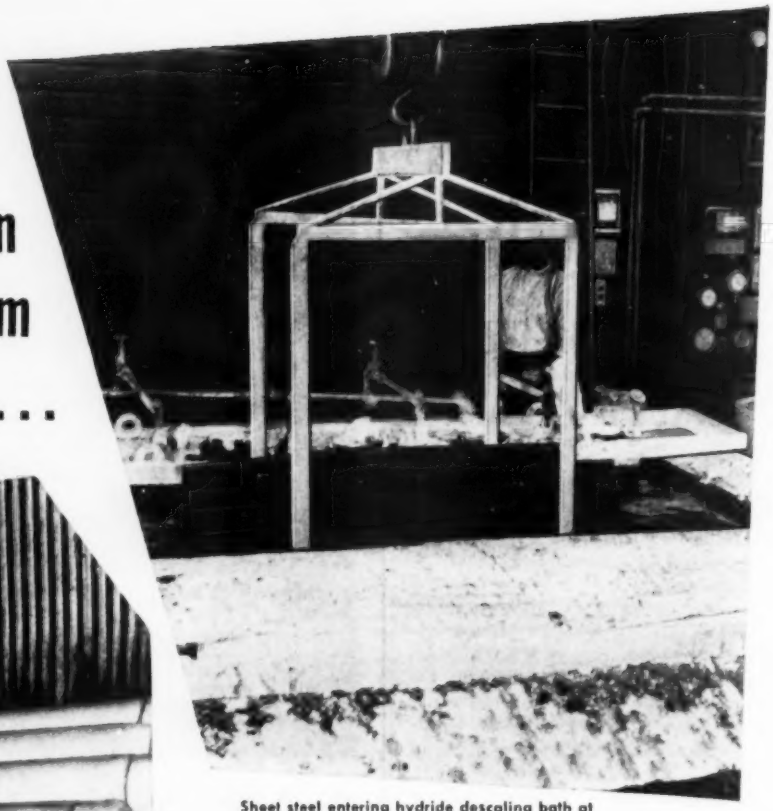
Although iron is plentiful, the scarcity of critical alloying agents such as manganese, chromium, nickel, molybdenum, tungsten, and columbium is causing a survey of all alloy steel specifications. Wider use of the wartime N.E. steels is being made, and the addition of boron to constructional steels is increasing as better knowledge of this application is spread among steel consumers. The report states that for steels in the range of 0.40% C, an addition of 0.002% B is equivalent to 0.30% Mn, or 0.35% Mo, or 0.5% Cr, or 2.0% Ni, so far as hardenability is concerned. Many steels for the aircraft, automotive, and machinery industries are being produced with boron additions for use in shafts, gears, and springs. Large savings in alloys are being made, notably in nickel.

Since nickel is critically scarce and the prospects of increasing production through the development of new deposits are poor, conservation through substitution has been most widely explored. Aside from the savings made with the use of boron, a much larger saving in nickel has been realized in the stainless steels. The success with which the straight chromium alloys (13 to 20% Cr) have replaced austenitic stainless steels (8 to 15% Ni) is responsible for a reduction of over 10,000 tons of nickel per year in this field alone. Accurate reports for 1952 are not available, but one stainless specialist has estimated that over 50% of the stainless steel melted (about 800,000 tons per year) is of the straight chromium variety. Nickel consumption in the U.S.A. during 1951 was about 170,000,000 lb. – a 14% drop as compared to 1950 – in spite of increased industrial activity. Since 1951, International Nickel Co. reports increased output of 15,000 tons per year; the reactivation of the plant at Nicaro, Cuba, will yield about 15,000 tons per year; the plant at Lynn Lake, Manitoba, is expected to produce 8000 tons per year; and the Kristiansand, Norway, plant of International Nickel Co. will supply an additional 15,000 tons per year. These expansions will add a potential supply of over 100,000,000 lb. per year and greatly improve the availability of this metal over that of early 1951.

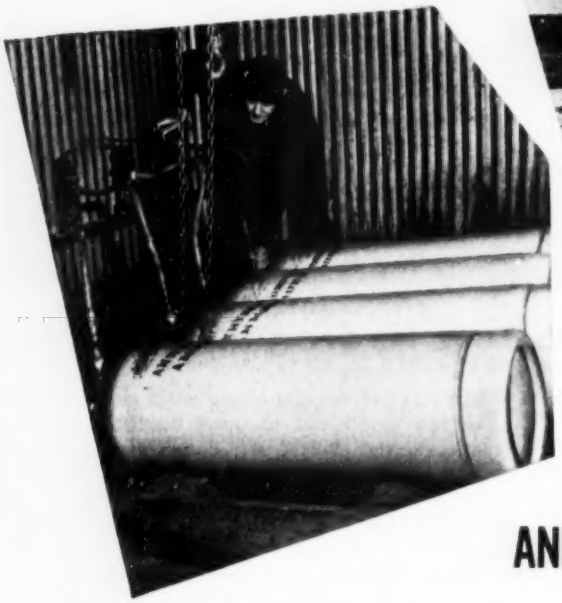
Imports of chromite in 1950 exceeded 1.5 million tons (a near record), while domestic production of this ore was only 400 tons. Metallurgical ore is obtained from only two sources, Turkey and Rhodesia, and this emphasizes the critical strategic situation in respect to this important metal.

(Continued on p. 175)

To obtain low-cost hydrogen for sodium hydride descaling...



Sheet steel entering hydride descaling bath at Universal Cyclops Company, Bridgeville, Pa.



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Metal Conservation

(Continued from p. 173)

American deposits of chromium are of very low grade; the prospects of getting increased production therefrom are quite dim and the processing of such ores apparently will be costly. Also, there are no satisfactory substitutes for this metal and the supply situation with respect to this metal will remain very critical. Stockpiling is the best solution at this time.

The manganese requirements grow steadily as steel ingot production increases. Consumption of 13 lb. of manganese per ingot ton demands 1300 million lb. of manganese for 100,000,000 tons of ingots. Attempts to reduce manganese levels in steel specifications have not been very successful and the target of 8 lb. of manganese per ton was not feasible in 1952. Since over 90% of the manganese is imported (31% from India, 22% from African Gold Coast, 21% from South Africa, and 8% from Cuba), the manganese supply situation is very similar to that for chromium. Domestic ores are of very low grade and deposits are usually small, while the cost of extracting ore of metallurgical grade (48% Mn) has not been economical, except for the Anaconda operation in Montana. Imports in 1951 were about 2.1 million tons of 48% ore, and consumers stock dropped 0.6 million tons in the same year. Shortages of transportation facilities in the ore-producing regions and limited availability of ocean shipping have retarded production throughout the world. As a result the price of standard ferromanganese (80% grade) has risen to $185 per gross ton (about 10¢ per lb. of manganese).

This combination of scarcity, cost and strategic factors has generated great interest in the recovery of manganese from steel slags. These constitute a tremendous reservoir of manganese; the recovery of this metal from daily slag production would overcome the shortage of manganese. Most American openhearth slags contain about 8% manganese, while the acid Bessemer slags contain 25% manganese. This manganese may be recovered by well-known smelting practices, but the cost of the extraction is still uncertain. Ore-dressing processes and chemical leaching methods have all been unsatisfactory in this field. The lethargy of steel and ferroalloy producers has greatly retarded this development. It is believed that steel mills should carefully store their slags on special dumps to avoid con-

(Continued on p. 176)

Metal Conservation

(Continued from p. 175)

tamination of these slags with other waste materials, as the time when these slags will be valuable is near.

In 1951 the situation regarding copper supplies was quite gloomy. American requirements necessitated importation of about 40% of the annual consumption; furthermore, the rapid depletion of American reserves will aggravate this condition within the next decade. The world-wide demand for copper, together with labor and political difficulties in Chile, the most important source of American imports, depressed this import trade from 506,839 tons in 1950 to only 363,000 tons in 1951. It was impossible to increase the strategic stockpile under these conditions. As a result, strict allocation of all copper supplies became necessary. Impositions of restrictions of the order of 30% of previous consumption developed and, as a consequence, many fabricators have had to turn to substitutes such as aluminum and its alloys.

Although aluminum was also scarce in the early part of 1951, considerable progress has been made in the application of aluminum tubing in steam condensers, as conductors in high-frequency current circuits and for long-distance, high-voltage transmission lines. Aluminum has also displaced copper as busbars in aluminum reduction plants. The attempt to make automobile radiators of this metal instead of copper has been unsuccessful, due largely to soldering and galvanic corrosion troubles in service. The probable continued scarcity of copper will have a profound effect on the aluminum industry.

It was expected that the copper supply problem would be eased in the latter part of 1952. Already world demand has diminished, exorbitant prices (up to 60¢ per lb.) in the free market have disappeared, and newly developed operations in the United States and elsewhere are expected to produce about 205,000 tons above present levels. The Anaconda Copper Co.'s Butte project will yield 125,000 additional tons by 1953, the Yerington, Nevada, project 30,000 tons, and the Phelps Dodge Corp.'s East Orebody project at Bisbee, Arizona, will begin large-scale production in 1954. Moreover, more copper from the old Michigan deposits are possible through subsidy arrangements with high-cost producers in that region. Other potential producers are the smelting plant at Chuquicamata, Chile, and the San Manuel deposit near Tucson, Arizona.

(Continued on p. 178)

Metal Conservation

(Continued from p. 176)

The British Specialist Team also reported aluminum as being in critically short supply in 1951. The American part of this picture has changed radically in the intervening ten months. The productive capacity of this metal is given as 805,800 tons at the end of 1951. Additional 650,000 tons capacity will be installed (in the United States) by 1953, and new plants for Canadian interests are being built in Jamaica and British Columbia. Many of these new plants are based on power generated from fuels, either from steam or natural gas combustion engines. New large deposits of bauxite ores in Jamaica and Haiti are being developed and this should improve both the strategic and availability factor for alumina. As a result, the projected aluminum supply for the U.S.A. will reach 1,500,000 tons within the next year and a half.

The United States imports nearly half of its lead. Production in 1950 amounted to 430,000 tons as compared to consumption of 810,000 tons. Manipulations of price ceilings on virgin lead and scrap lead caused confusion, and labor troubles at the mines also retarded production somewhat. However, during the early part of 1952, foreign demands decreased and the whole lead market softened to such an extent that the price of the metal dropped 2¢ per pound. There is not much hope of finding substitutes for lead and there has been little success in developing new deposits in the United States. It is obvious that stockpiling of lead may be continually necessary in the future.

Zinc is similar to lead in consumption and availability. Domestic production in 1951 was 586,000 tons, consumption amounted to 919,400 tons and imports were 370,000 tons. Shortage of this metal caused restrictions in several fields, such as die casting and galvanizing, which effected a saving of about 10% in zinc requirements. In the last year, imports of zinc have increased and new mines are being developed throughout the world. Estimated reserves of zinc ore in the world are now estimated as sufficient for 40 years, and zinc supplies in the next few years appear to be adequate. Recent decrease in the price of zinc in the world market supports this conclusion.

The tin supply remains extremely tight, but the Bolivian and East Indian producers have been hampered by political trouble and no new sources have been found. In spite of this, world production in 1951 nearly

equaled the output in 1950. Tin consumption dropped from 71,190 tons in 1950 to 56,700 tons in 1951; total stocks in the U.S.A. decreased from 72,887 tons to 49,482 tons. Government authorities intimated that further limitations on the use of tin would have to be imposed.

Magnesium production has grown from a low of 5000 tons in 1945 to 20,000 tons in 1950. Increasing use of castings and sheets in plane and truck construction has permitted the installation of needed new equipment for processing this metal. The magnesium bomb is apparently obsolete; requirements for this item are therefore unimportant. Some new planes use as much as 10 tons of magnesium and the projected expansion of the airplane industry created a temporary shortage of magnesium. This was being overcome in 1952 and supplies of this metal should increase in the next few years. Electric power shortages might have some influence in retarding production.

The world production of molybdenum comes mostly from the U.S.A. Consumption of this metal in 1951 increased 30% over 1950. Demand is so great that strict allocation had to be imposed on its use. Output amounted to about 15,000 tons (contained molybdenum) in the first nine months of 1951 and consumption was so high that stocks of concentrates on hand were reduced about 60%. Good substitutes for this metal are not available; in fact, the shortage of tungsten has become so critical that part of the increased molybdenum demand is the result of substituting this metal for tungsten. The possibilities for new mines are not promising.

Increased demand for tungsten in the armament program, combined with loss of production in Korea and China, makes it difficult to assess the future for this vital metal. Strict allocation orders, suspension of duties on imports and subsidized purchasing arrangements for tungsten-concentrate producers have all been instituted. Domestic production in 1951 increased 50% over 1950. Consumption rose to 9435 net tons (60% WO_3 basis) in the first nine months of 1951 as compared to 3940 net tons in 1950. The very critical scarcity of this metal is evident and there is little prospect of early improvement in the situation.

Consumption of cobalt reached an all-time record in 1951 (3700 tons in the first nine months). Domestic production was 350 tons, while imports came to 3100 tons. Cobalt-chromium-molybdenum alloys for jet engines consumed 48% of the cobalt, magnet alloys 21%, and more cobalt was used

(Continued on p. 180)

Metal Conservation

(Continued from p. 179)

in high-speed steels and cemented carbides. The largest source of supply was the Belgian Congo and new facilities will increase the output from that country. New sources of cobalt include the recovery of the metal from nickel matte practiced in Canada, new workings in French Morocco, and the Calera Mining plant in Idaho which is expected to yield 1600 tons a year (three times the previous American output). In spite of this, increasing demands in the important fields of its application are expected to keep the demand well above production. The English have successfully reduced cobalt requirements for jet-engine components.

The recommendations of the British team at the conclusion of their survey in June and July, 1951, urged renewed attention to the following:

1. Steels of much lower alloy than heretofore, particularly having alloy additions well below those specified for the British Standard En Steels (B.S. 970).

2. The need, or otherwise, of complete hardening throughout the section of the part prior to tempering.

3. The value of the hardenability approach for steels having very low alloy content.

4. The established usefulness of small boron additions.

5. The recovery of manganese from basic openhearth slags.

With regard to the nonferrous metals, the team reached the following conclusions:

1. Most nonferrous metals are in very short supply in the U.S.A. While there are appreciable differences in the degree of shortages, production is already hampered. It is apparent that the Western nations will avoid curtailment of output in the engineering field only by effecting the most strict economies in the use of nonferrous metals.

2. Industries producing aluminum and magnesium have great vitality. There are considerable prospects for rapid expansion. If these prospects are realized, then these metals are likely to act as alternates for other metals in shorter supply.

3. The long-term prospects for some nonferrous metals, notably copper, lead, tin, tungsten, cobalt, cadmium, are not good. In many instances, copper may well be replaced by alumium.

4. In certain fields the substitution of magnesium for zinc is taking place.

5. Vigorous short-term conservation measures are being taken with nickel and lead.

E. C. Wright

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Warm Rolling of Metals*

THE ORIENTATION textures of cold reduced low-carbon strip steels have been extensively studied over the past 25 years. While many of the factors which influence the rolling textures are well known, it is surprising that effect of temperature at which the strip was deformed has not been given due consideration. When strip steel is plastically deformed on two-high mills under fixed conditions, the rolling textures are surprisingly similar.

However, with the development of the modern four-high rolling mills, greater rolling speed and reductions became practicable. X-ray diffraction studies, made on strip steels rolled on these mills under exactly the same conditions, often exhibited a great difference in the rolling textures. The differences observed required explanation.

In some continuous rolling mills the strip may be reduced in excess of 80% in thickness; the steel which enters the mill is cold, but the friction and the stretching of the strip as it passes through each stand may, in time, increase the temperature to over 500° F. Stainless steels rolled on the Steckel reversing mill may at times reach 600° F. In general, strip steels which work harden rapidly usually reach temperatures in the range of 350 to 500° F. during the rolling process. The energy consumed in the deformed strip appears largely in the form of heat, although a small fraction is stored as latent energy.

EXPERIMENTAL DETAILS

Specimens of low-carbon steel (0.10% C) were rolled on a small laboratory mill. The total reduction (72%) and the number of passes through the mill were the same. The only variable was the temperature of the strip entering the mill. The specimens were rolled at 32° F., room temperature (72° F.), 212° F. and between 300 and 800° F. at 100° F. intervals. The temperature of the strip was checked with temperature-indicating crayons for all temperatures above 300° F.

The X-ray patterns were made by the reflection method because of its several advantages over the transmission method, especially in the

(Continued on p. 184)

*Digest of "The Effect of Temperature on the Rolling Texture of Plastically Deformed Low-Carbon Strip", by Norman P. Goss, a paper presented at the Annual Convention of the American Society for Metals, October 1952.

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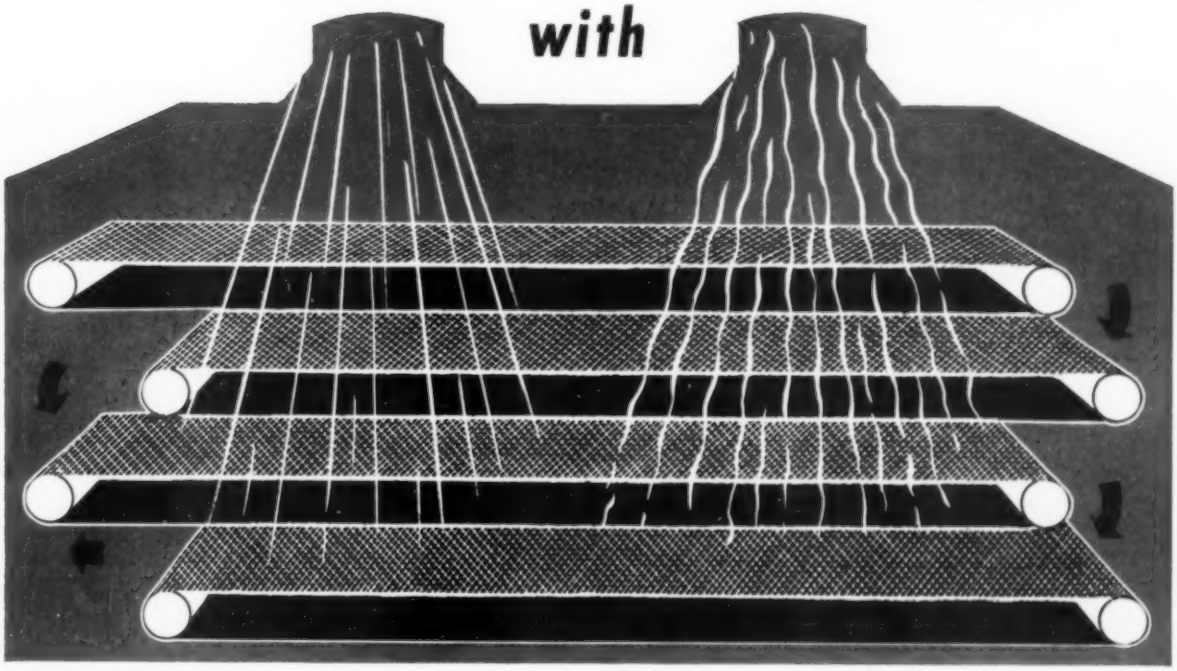

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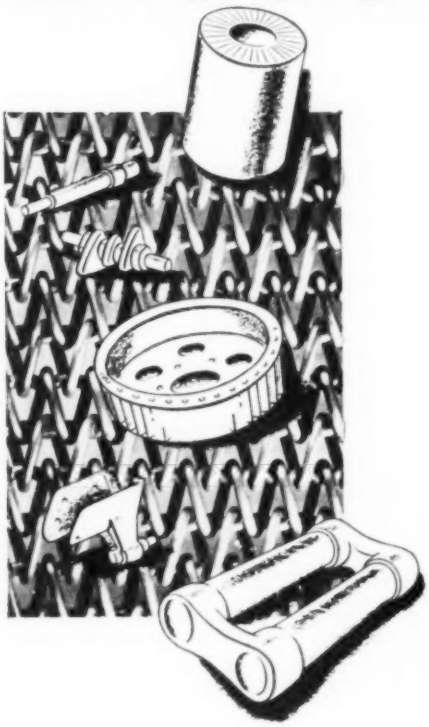

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Warm Rolling of Metals

(Continued from p. 182)

preparation of the specimens, the surface of which requires only a light etch. Also the depth of penetration for the X-ray beam is automatically fixed when the specimens are set at some fixed angle to the X-ray beam. The angle chosen is some important Bragg angle, and in this instance it was 10°. At this angle the (110) planes will reflect the K_α radiation from a Mo target operated at 35,000 v. By using this method it is at once (by direct examination of the X-ray pattern) known how the (110) planes are distributed with respect to the surface and the rolling direction. To obtain the pertinent data required for the investigations, the specimens were X-rayed as follows:

Two diffraction patterns were made from each cold rolled specimen, one with the X-ray beam making an angle of 10° with the surface and lying in the plane which coincides with the rolling direction and perpendicular to the rolling plane. The other X-ray diffraction pattern was made by reflecting the incident beam at 10° to the surface, but with the reflected beam lying in a plane perpendicular to the rolling surface and the rolling direction. These directions are usually referred to as the P_0 and T_0 directions.

Experience has shown that the orientation texture develops more readily and perfectly in the T directions than in the P and N directions. With these facts in mind one should expect that the effect of temperature upon the rolling texture should be most sensitively shown when the strip steel is examined in the T direction. Enough data are disclosed in the P_{10} and T_{10} diffraction patterns for a complete pole-figure determination.

RESULTS

The specimen rolled at 32° F. exhibited the strongest orientation texture and of the type (100)(110). Experimental rollings at temperatures below 32° F. indicated that the perfection of the orientation texture increases. No attempt was made to determine the temperature at which the orientation texture was most perfectly developed.

Rolling at room temperature generally does not produce a strong, well-developed texture of the type (100)(110). Numerous X-ray patterns indicated that a large number of crystallites remained in random orientations. *(Continued on p. 186)*

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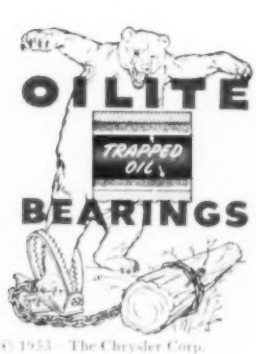

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Warm Rolling of Metals

(Continued from p. 184)

The greatest changes in the rolling texture occurred when the low-carbon steel strip was rolled at 400° F. The rolling texture was strikingly random in appearance.

A new orientation texture was observed in the specimen rolled at 700° F. The new texture is very strongly developed, and appeared to be of the type (110)(100).

Generally, steels rolled in the range of 250 to 600° F. have a high percentage of crystallites in random orientation. The development of a perfect orientation texture, and random orientation textures, depends largely upon the temperature at which the deformation is carried out. The cold rolling texture is of the type (100)(110), and it is suggested that low-carbon steels deformed at a temperature which favors the (110)(100) texture be referred to as the warm rolling texture.

PRACTICAL APPLICATION

The experimental work of Andrade and Tsien has shown that, for cubic metals, the slip mechanism is temperature-dependent. Nadai has further pointed out that the temperature of deformation profoundly influences the slip mechanism. Such important theoretical observations should have great practical value in due time. Should these be of importance, the temperature of deformation could easily be adjusted on the modern four-high rolling mills. These can be operated over a wide range of temperature, and in a practical manner.

A few examples are presented to illustrate the potential importance of the warm rolling of metals. It has been found by experience that the surface finish of magnesium is influenced by the rolling temperature. The physical properties are also temperature-sensitive. Stainless steels when warm rolled appear to be more ductile, the γ to α transformation is suppressed, and lower roll pressures are required. Silicon ferrite electrical strip is easier to roll when warm rolled. These alloys work harden rapidly, and temperatures as high as 500° F. may be attained. The ductility of warm rolled silicon ferrite is high.

It is believed that the temperature at which a metal or alloy is deformed will receive more serious consideration in the future. While the experimental work in the field of warm rolling has not been extensive,

(Continued on p. 188)

Warm Rolling of Metals

(Continued from p. 186)

the theoretical work reported strongly suggests that the "temperature effect" will in some instances be an important consideration.

Use of this technique with many nonferrous metals may permit control of orientation texture by rolling in the temperature range where random orientations develop. This is possible when several orientation textures exist in the so-called warm rolling range.

Carbon Restoration During Continuous Annealing*

STRENGTH AND HARDNESS LEVELS on the surface of heat treated parts, such as cap screws, bolts, kingpins and springs, are of great importance. Decarburized surfaces on steels used for such parts may be machined off or the carbon can be restored by carburizing or cyaniding. In some cases, it is commercially practicable to use a carbon restoration process during the annealing cycle to eliminate the decarburized surface of the steel. With a constant carbon content extending to the surface, more uniform properties can be obtained with conventional and induction hardening processes.

The technical basis of carbon restoration lies in the fact that the composition of a gaseous atmosphere containing methane (CH_4), carbon monoxide (CO), carbon dioxide (CO_2), hydrogen, water and nitrogen can be adjusted so that at any given austenitizing temperature it will be in equilibrium with a particular carbon content in the steel. Of these gases, methane and carbon monoxide are carburizing, while carbon dioxide, water and hydrogen are decarburizing. Nitrogen is inert. The carburizing reactions in this system may be written as follows:

$$Fe + CH_4 \rightarrow Fe(C) + 2\,H_2$$
$$Fe + 2\,CO \rightarrow Fe(C) + CO_2$$

Reactions in the gas atmosphere may be written as follows:

$$CH_4 + H_2O \rightarrow CO + 3\,H_2$$
$$CO + H_2O \rightarrow CO_2 + H_2$$

The carbon potential of the atmosphere can be obtained from analysis or predicted from its dew point. In the range of commercial

(Continued on p. 190)

*Digest of "Continuous Annealing With Carbon Restoration", by J. D. Armour, *Industrial Gas*, Vol. 31, October 1952, p. 3.

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Carbon Restoration During Continuous Annealing

(Continued from p. 188)

practice, the carbon potential will be changed by about 0.05% for a 0.02% change in CO_2 content. A similar change in carbon potential would bring about a dew point change of 1.5° F. With standard testing methods, a 1.5° F. change in dew point is easily measured while a 0.02% change in CO_2 content is very difficult to measure. The dew point of the gas is, therefore, a convenient measure of its carbon potential.

Recently, a continuous annealing furnace incorporating carbon restoration was installed at the Union Drawn Steel Division of Republic Steel Corp. Prior to the installation of this roller-hearth furnace, all carbon restoration during annealing was done in batch-type car-bottom furnaces. A comparison of capacity between the continuous and the batch-type furnaces on the basis of per dollar invested shows that the continuous furnace has from 110 to 240% greater productive capacity.

Control of the atmosphere was made possible by properly placed atmosphere inlets, adjustable throats on either end of the furnace, water cooled doors, effective air curtains and recirculating fans. Time-temperature cycles are readily controlled in the range of 1 to 24 hr. and 1400 to 1800° F. Bars of 6 in. diameter and coils up to 54 in. diameter may be processed.

The over-all design and operating details on the furnace are discussed. Briefly, the furnace has an over-all length of 60 ft. and an effective width of 4½ ft. It is divided into six zones that can be independently controlled as to temperature and atmosphere. Standard W-shaped alloy radiant tubes are used, and the furnace is so piped that the tubes may be used for heating or cooling. Some interesting design features are incorporated for charging and discharging the furnace in order to avoid air contamination during the processing of coils. Two types of prepared atmospheres are used. RX and natural gas for enrichment are used to maintain the carbon potential in the high carbon zone; at the lower holding temperatures the inert gas NX is mixed with the carbon-balanced atmosphere from the hot zones. Typical furnace cycles most frequently used in the carbon restoration annealing of plain carbon and constructional alloy steels are given.

D. J. Ghiardi

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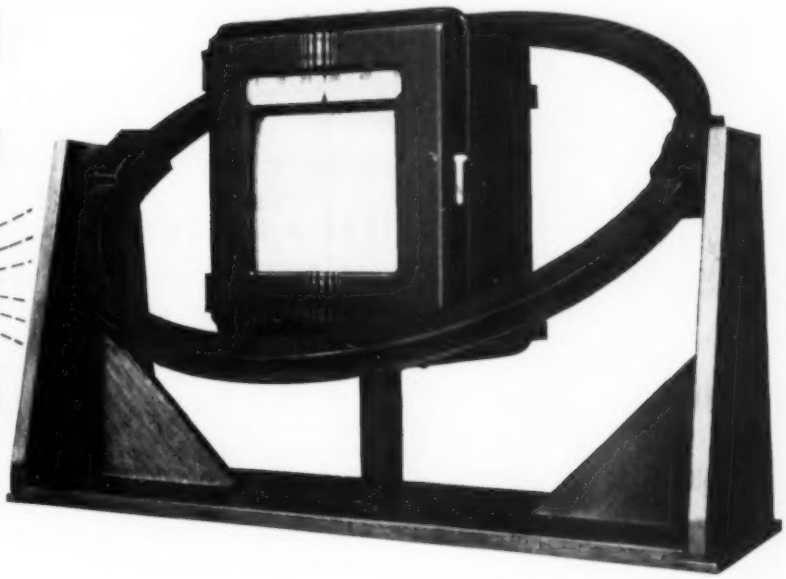

● Built into every Speedomax recorder and controller is a high degree of indifference to stray electrical fields. And this is one of its most useful characteristics in almost any job. It means that you can install a Speedomax near a big motor, power line or X-Ray machine—any electrical equipment in fact—and you'll probably see no effect at all from surrounding electronic noise and "junk".

The reason for this indifference to stray fields goes back through the adjustment, building and design of the instrument, to its basic engineering. Speedomax has an *electronically-clean measuring circuit*, as well as clean signal and amplifier circuits.

This clean design includes a bifilar-effect slidewire, to eliminate any objectionable inductance at that point. It includes our "no-moving parts" trolley contact on the slidewire, which eliminates pigtails and their variable inductances. It includes use of a Mumetal slidewire shield where desirable, instead of less expensive but lower-permeability aluminum. And it includes a lot of just downright meticulous detailing, such as carefully engineered wiring and input filtering, plus ingenious shielding where required.

These and other precautions eliminate out-of-phase components in the supply to the amplifier. The latter therefore doesn't "load"; hence sends the correct amount of correct-phase power to the balancing motor. With ample power, the motor's recording and control action is snappy and accurate.

Our Catalog ND46(1) and Technical Publication ND46(1) tell the story. Write our nearest office or 4927 Stenton Avenue, Philadelphia 44, Pa.

Industry's engineers find that Speedomax instrument performance is not affected by the stray fields created by motors, electric furnaces, magnets, power lines and so on.

PHOTO COURTESY LACLEDE STEEL CO.

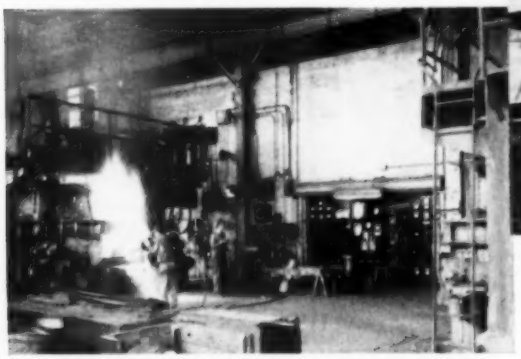

PHOTO COURTESY A. CASTINGS MANUFACTURER.

Art Ad ND46 10

LEEDS NORTHRUP

instruments automatic controls • furnaces

Polarized-Light Metallography of Uranium*

GREAT EMPHASIS has been placed on the need for critical alignment of all parts of the optical system for significant results in all metallographic work employing polarized light. Suitable objectives and good polarizing units are essential in this work.

The authors have used commendable judgment in stating the make and model of microscopic instruments used in their investigation. This information is important in evaluating results from any intensive polarized-light work. They have used both a Beck Universal and a Vickers microscope and reference is made to the minor modifications that were necessary for both instruments. There are many metallographs in use at present having fixed polarizing units which are precisely aligned in advance and one does not rotate analyzer with respect to polarizer. These polarizing units are of very high quality and are of exceptional value in research work. It is simply necessary that one be familiar with the characteristics of the particular optical system used to be aware of the possible variables. This is certainly true when information on the number of maxima and minima of light intensity per rotation of the stage is being discussed.

The authors and reviewer agree that polarized-light techniques provide the only satisfactory means for examination of uranium structures. Also, conventional mechanical polishing is limited to studies of second phases, inclusions or porosity. It is understood that care must be taken during preparation of surfaces which are to be used for the study of deformation twins. Examination by back-reflection X-ray showed diffuse patterns from all surfaces polished mechanically, but electrolytic polishing accomplished complete removal of worked metal to approximately 0.4 mm. below the surface. This depth of cold-working is about the same as reported for magnesium, but is greater than 0.03 mm. found for aluminum.

Reference is made to previous work by Chipman and by Cahn on the common occurrence of deformation twins in uranium. The twins result from anisotropic expansion,

(Continued on p. 194)

*Digest of "The Metallography of Uranium", by B. W. Mott and H. R. Haines, *Journal* of the Institute of Metals, Symposium on Properties of Metals, Vol. 80, 1951-52, p. 621-627.

Polarized-Light Metallography of Uranium

(Continued from p. 192)

and the form and extent of twinning depend on the rate of cooling in the α range. Multiple twinning provides interesting microstructural patterns. Some twins intersect without any apparent interference; others appear to suffer some displacement. Change in intensity at junctions of interpenetrating twins indicates that the orientation at the intersection of two twins is different from that of either twin, but is related by a shear direction common to both twins.

Heat treatment and recrystallization of uranium which has been cold worked by swaging is governed by the degree of reduction. Very few nucleus grains were produced in material annealed at 750° F. for 5 hr. when the reduction was 35% or greater. At lower reductions no change was observed. By increasing temperature to 785° F. and time to 3 days, an entirely recrystallized, fine structure was produced in material reduced 35%. It follows that increasing the temperature to the range of 930 to 1200° F. reduces the time to periods of 1 hr. or less for complete recrystallization and also lowers the amount of reduction that is necessary.

In metallographic procedures for uranium, the electrolyte used first was that originally recommended by Chipman. It was later varied at Harwell in England by replacing the ethylene glycol with glycerol because it was more readily available. Also the amount of alcohol was reduced so that the composition consists of equal parts of phosphoric acid, glycerol and ethyl alcohol.

About one hundred electrolytes were investigated. The best contains 1 volume orthophosphoric acid, 2 volumes sulphuric acid and 2 volumes water. It involves continually wiping with a camel's-hair brush during polishing to remove anodic film. It is faster and produces a flat surface with less attaching of inclusion particles.

Perchloric acid (60%) used alone is not recommended for properly revealing microstructures. It is suitable for fast removal of large quantities of worked metal from surfaces for X-ray examination. Mixtures of acetic acid and perchloric acid in varying proportions are used but do not provide very good contrast.

The most recently developed electrolyte is based on pyrophosphoric

(Continued on p. 196)

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Polarized-Light Metallography of Uranium

(Continued from p. 194)

acid, and employs 10 g. pyrophosphoric acid, 10 g. chromium trioxide, 40 ml. orthophosphoric acid, 100 ml. sulphuric acid and 200 ml. distilled water.

Electrolytic polishing deposits an oxide film up to 200 A thick on uranium. There is doubt as to the structure of the oxide which may be cubic UO_2 or orthorhombic U_3O_8. High temperature increases the thickness of the film until the specimen is no longer optically active under polarized light.

Angular inclusions commonly found in uranium reflect a light gray color in white light. Some of these were separated and found by X-ray examination to be the cubic UO_2.

As has been observed in other metals, two different sets of grain boundaries are sometimes evident on a uranium surface after certain annealing treatments. The first set of grooves outlines the initial grains and becomes "recorded" by thermal etching during heating prior to grain growth. Upon reaching the proper temperature for grain growth, the boundaries move with sufficient smoothness so as to leave no further marks until finally relocated after grain growth has stopped. Thermal etching upon cooling then records a second and deeper network of new grain boundaries.

Elimination of (or compensation for) stray polarization effects in optical equipment would permit precise examinations of preferred orientation. Contemplation of this is stimulating in view of the need for such evaluation of anisotropic metals other than uranium.

H. P. Roth

Recent Improvements in Steelmaking

(Continued from p. 112)

a ratio of 2 oxygen to 1 natural gas was noted; with propane, a ratio of 5:1 would be about right. For low-alloy steels a covering of ordinary glass slag was recommended.

AUTO-POURING OF INGOTS

The interesting subject of "Auto-Pouring" was discussed by T. J. Hoby, assistant foreman of Republic Steel Corp., South Chicago. It was developed by Republic's Steel and

(Continued on p. 198)

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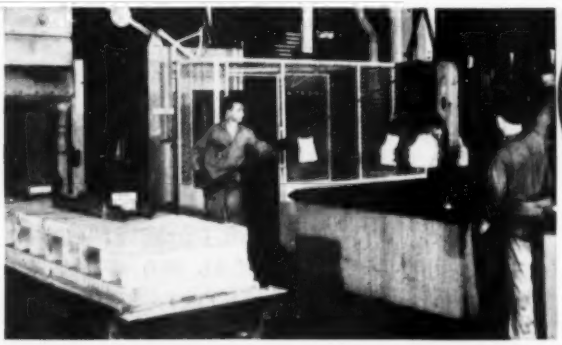

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Park CHEMICAL COMPANY

Recent Improvements in Steelmaking

(Continued from p. 196)

Tubes Division, and may be described as a method of pouring steel in which the stopper rod slide is hydraulically moved upward or downward. Movement is controlled by an electrically energized pushbutton box in the hands of the steel pourer. Equipment includes a motor pump unit with an electrically controlled valve system for regulating the flow and pressure of the hydraulic fluid through two connecting hoses to the hydraulic cylinder which actuates the stopper rod.

Advantages of the Auto-Pour over the conventional lever pour are safety, easier operation, and better pouring. South Chicago operations have definitely been improved in the openhearth shop. An average of 83% O.K. pour ingots prior to installation of the Auto-Pour was increased to 93%. Very little improvement has been recorded in the electric shop where 95% O.K. pour ingots is usual with conventional equipment and methods.

It is no longer necessary to prick open nozzles on cold heats and it is almost impossible to determine whether a ladle is skulled or not, as judged by shut-off evidence during pouring.

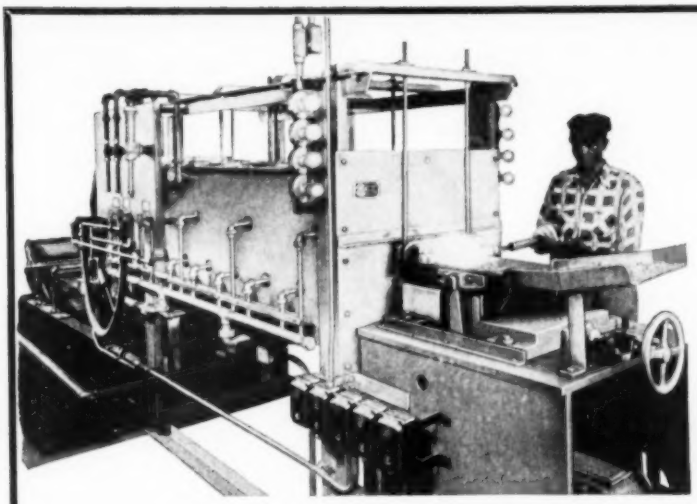
H. R. Loxterman, manager of steel plant equipment for Blaw-Knox Co. of Pittsburgh, described development work on automatic pouring. His firm has a unit which uses a lever to operate the hydraulic cylinder, thus eliminating the pushbutton station and solenoid valve.

In an installation for No. 5 openhearth furnace at Homestead is a monorail which carries the power unit; a pushbutton station will be used for operating automatic pouring. A pressure of 250 psi. in the hydraulic cylinder will produce 6000 psi. at the stopper head. An experimental unit will also be installed at the Union Steel Castings Division in which the power unit will be mounted on a crane.

SUBSTITUTE SOURCE OF CHROMIUM

N. B. McFarlane, assistant to the president of Pittsburgh Metallurgical Co., Inc., of Niagara Falls, N. Y., opened a discussion of substitute sources of chromium for low-carbon chromium stainless steels. Virtually all producers of stainless steel are now using some material to replace

(Continued on p. 200)



A.G.F. Model No. 166 Continuous Reciprocating Furnace and Automatic Quench Tank installation in the Chicago Screw Company plant at Bellwood, Illinois.

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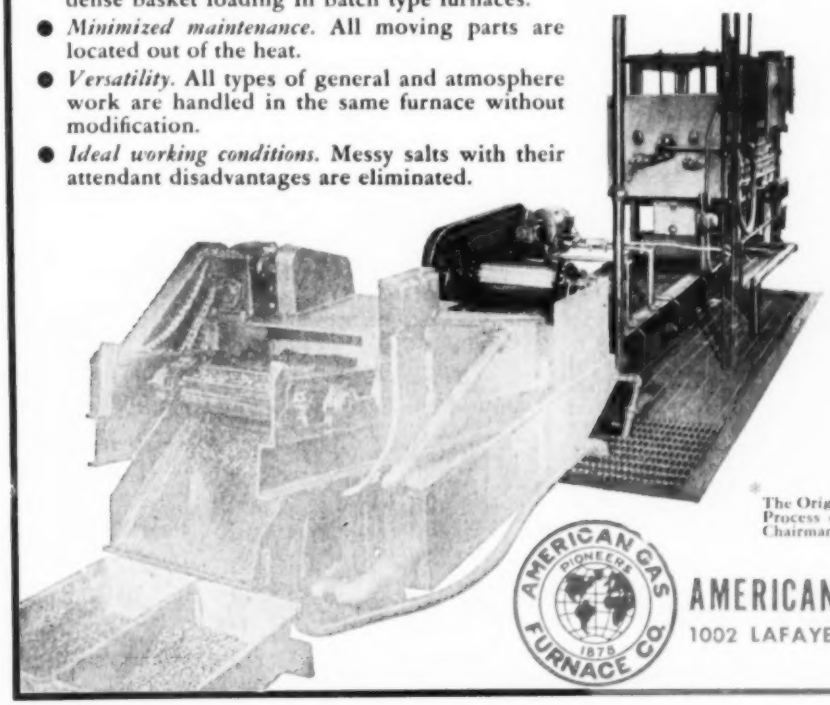

Discharge end view of the in-line continuous type installation of Reciprocating Furnace and Quench Tank at the Chicago Screw Company.

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Recent Improvements in Steelmaking

(Continued from p. 198)

low-carbon ferrochromium and thereby reducing costs and improving quality. The trend is to use as much stainless scrap as possible, thus cutting down on the amount of final additions to adjust the chromium analysis. If a 25-ton heat contains 50% stainless scrap, this would furnish enough chromium so the bath would analyze 8.50% chromium and the rest of the chromium would have to come from the low-carbon ferrochromium addition. If the charge is blown down to 0.04% carbon with oxygen, about one half the chromium is oxidized and enters the slag. If low-carbon ferrochrome-silicon is used (instead of ferrosilicon) to reduce this oxidized chromium from the slag, 930 lb. of metallic chromium would be added in the example cited, along with the 1100 lb. of necessary silicon. Chromium from such a source costs 8¼¢ per lb. less than the price of chromium in low-carbon ferrochromium; therefore a substantial saving is made.

One variation of the stainless scrap practice is the addition of enough high-carbon ferrochromium to the charge to bring the total chromium up to 17%. Some of this is oxidized during meltdown, but it is cheaper to reduce it back into the bath, even at 90% recovery, than to add chromium as low-carbon ferrochromium. Therefore, the practice of using stainless scrap, high-carbon ferrochromium and low-carbon ferrochrome-silicon (chrome-silicide alloy) is widespread.

Another method of decreasing costs is by the use of chrome ore. In this a certain amount of ore (which will yield about 4% of metallic chromium) is charged and reduced with the low-carbon ferrochrome-silicon alloy – a method reminiscent of Wild's English process introduced 25 years ago, in what is now Armco's Baltimore plant, of adding chromium to a low-carbon steel bath by successive additions of chrome ore and ferrosilicon. The modern adaptation leads to the lowest ingot cost of all the practices discussed at this Pittsburgh meeting. The total amount of chromium originating in the scrap is only 8.50% of the metallic bath, and the balance to produce a 17% Cr steel comes from the chrome ore (33% grade) and the low-carbon ferrochrome-silicon used as reducing agent. A typical charge for a 25-ton heat would be:

25,000 lb. stainless scrap (17% Cr)
6,000 lb. chrome ore (33.00% Cr)
2,500 lb. mill scale
16,000 lb. straight carbon steel scrap
6,500 lb. low-carbon ferrochrome-silicon

Analysis is adjusted by small additions of low-carbon ferrochromium.

J. J. Wyandt, assistant superintendent of Republic Steel Corp.'s melt shops in Canton, Ohio, discussed practice on 50-ton heats of 17% chromium stainless (Type 430). Plain carbon scrap is melted down and the meltdown slag is removed prior to any subsequent high-carbon ferrochromium additions, primarily to prevent reversion of phosphorus from this slag. Two successive 9000-lb. additions of high-carbon ferrochromium are then made, and carbon blown out by oxygen after each addition. Low-carbon ferrochrome-silicon is added to the slag at each step to reduce the oxidized chromium. If the original charge contains stainless scrap, the amount of high-carbon ferrochromium added after meltdown will depend on the chromium in the charge.

Practice at the Duquesne Works, U. S. Steel Corp., was outlined by A. C. Ogan, superintendent of the electric furnace department. A

(Continued on p. 202)

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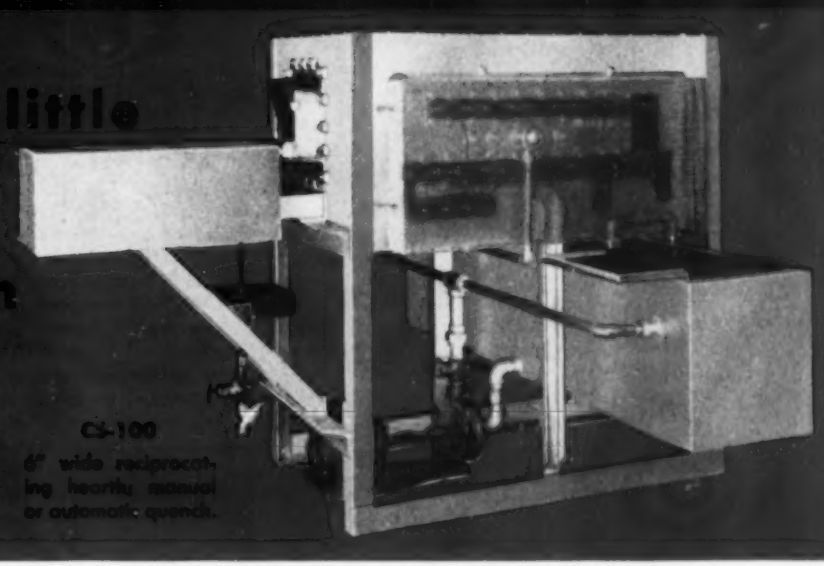

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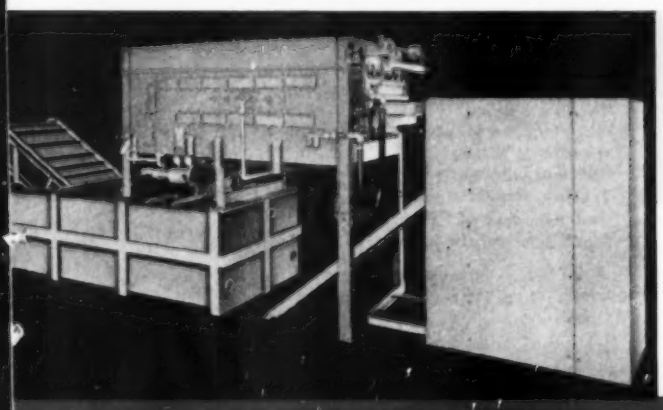

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Recent Improvements in Steelmaking

(Continued from p. 200)

charge containing 50 to 70% stainless scrap is favored for A.I.S.I. Type 430, and enough high-carbon ferrochromium is added to get 15 to 16% chromium in the bath. After the oxygen blow some slag is added to cool the bath. A 90% recovery of chromium is about the maximum, and this is not obtained on 0.04 to 0.05% carbon melts.

Frank Brooke, consultant, recommended that scrap be preheated to 1550° F. before top-charging into electric furnaces. At this temperature the plasticity of the scrap is sufficient that it can be compressed by lowering a heavy weight into the preheating bucket. Any oil or water is eliminated and defects arising from hydrogen should be minimized or at least be less than with conventional charging of cold scrap. An interesting point is that above 1550° F. the scrap is nonmagnetic and melts faster with the lower electrical losses from impedance. Thus, a great saving in power required in the early part of a meltdown with the usual cold magnetic charge can be made.

ACID AND BASIC ELECTRIC STEEL

Considerable interest was shown at the sessions devoted to comparison of acid and basic electric steel for castings. This might be attributed to two factors: *(a)* The problem associated with the gradual increase in sulphur content of purchased scrap, and *(b)* the improvement in mechanical properties, especially the impact quality of basic steel, due to lower phosphorus and sulphur contents. P. J. Neff of American Steel Foundries stated that, on the basis of their experimental work, it is not necessary to discriminate between acid and basic steel in the control of tapping temperatures, or in selection of castings to be poured at the time these casting tests were made.

General experience on all products of both types of steel has shown little difference in misruns if all conditions of melting and pouring of heats are held under control. Exceptions can occur, particularly in the basic operation, if the proper slag volume is not maintained on the ladle during pouring. Experiences with basic practice indicated that a decreased amount of slag on the ladle permitted higher heat losses with a corresponding decrease in metal temperature. The so-called sluggishness of the basic steel is not considered a specific characteristic of the steel but a direct result of temperature loss. Work on the relation of hot tears to acid and basic electric furnace practices showed the basic electric steel with its lower sulphur to be less prone to hot tearing than acid electric steel.

J. W. Juypenlatz and T. S. Quinn reported on the experience of Lebanon Steel Foundry in changing two 2-ton furnaces from acid to basic operations. The savings of manganese or chromium by the basic process are significant, and with high alloy metals the superior recoveries possible with this process are of major economic importance.

Fluidity of basic steel, with particular respect to pouring small castings, was not the problem anticipated. The condition of fluidity may be promoted by controlled melting procedures which avoid the use of carbide-type slags before final deoxidation. When temperatures below 2750° F. were reached, it was noted that basic metal near the freezing appeared to freeze more rapidly and skull over. Charpy V-notch impact tests on 100 heats of quenched and tempered S.A.E. 8630 gave impact values that were about 30% higher for the basic steel.

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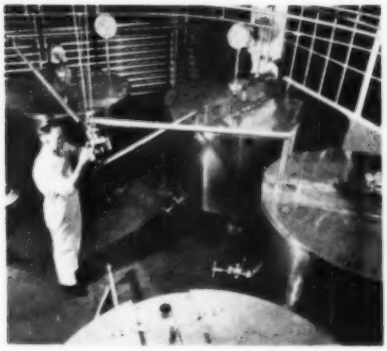

The latest processing and production equipment for the food, chemical and petroleum industries is made of stainless steel. Practically unaffected by the corrosive action to which it is constantly subjected, this new equipment helps keep production costs down, greatly facilitates quality control.

Automotive applications for stainless steels become more numerous with each year's new-model cars and trucks. Today they include such diverse items as exhaust valves and door handles, water pump shafts and radiator grilles, decorative trim and truck bodies.

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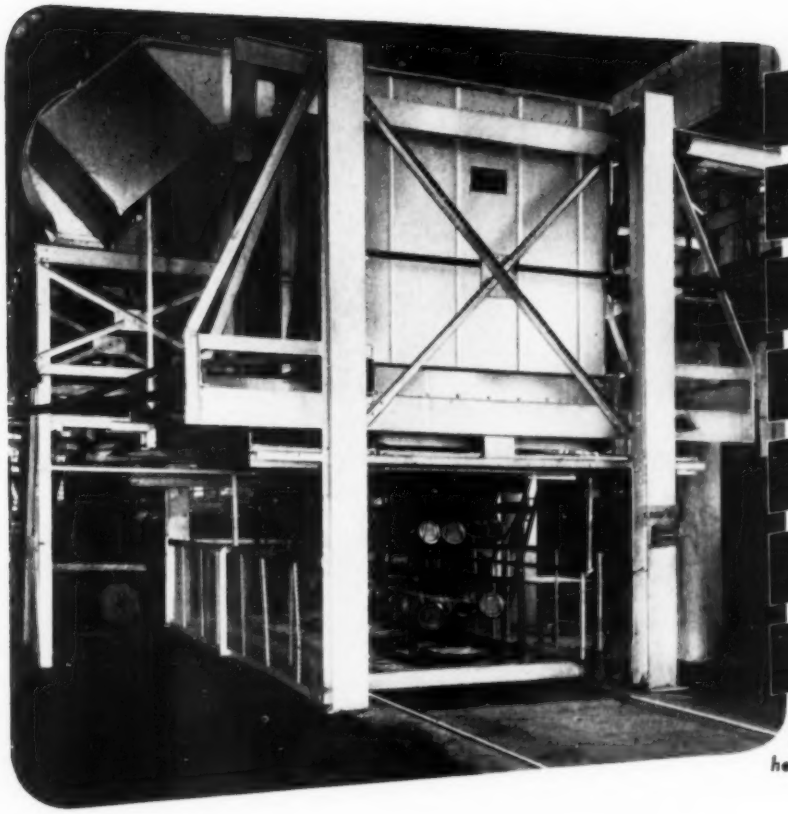
heat treating ovens

for



- ANNEALING
- SOLUTION HEAT TREATMENT
- AGING PROCESSES
- NORMALIZING AND STRESS RELIEF
- HYDROGEN RELIEF AFTER PLATING
- PREHEATING PROCESSES
- TEMPER DRAWING

Rapid quench oven for heat treating aircraft parts

Whatever your heat treating problem, you can be sure there is a Young Brothers Oven made to handle it with maximum efficiency. Young Brothers Ovens, batch and conveyor types with accurately controlled temperatures up to 1000°, are speeding up production in every type of metal-working plant.

Through the services of Young Brothers engineers, you get the advantage of over 56 years of experience in building ovens for your specific needs. These services—available to you without obligation—will help you increase your production and cut costs. Write or call for more details.

STANDARD AND SPECIAL TYPES TO MEET PRODUCTION REQUIREMENTS AND PLANT CONDITIONS FOR ALL PROCESSES

Write for Bulletin 14T

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Established 1896

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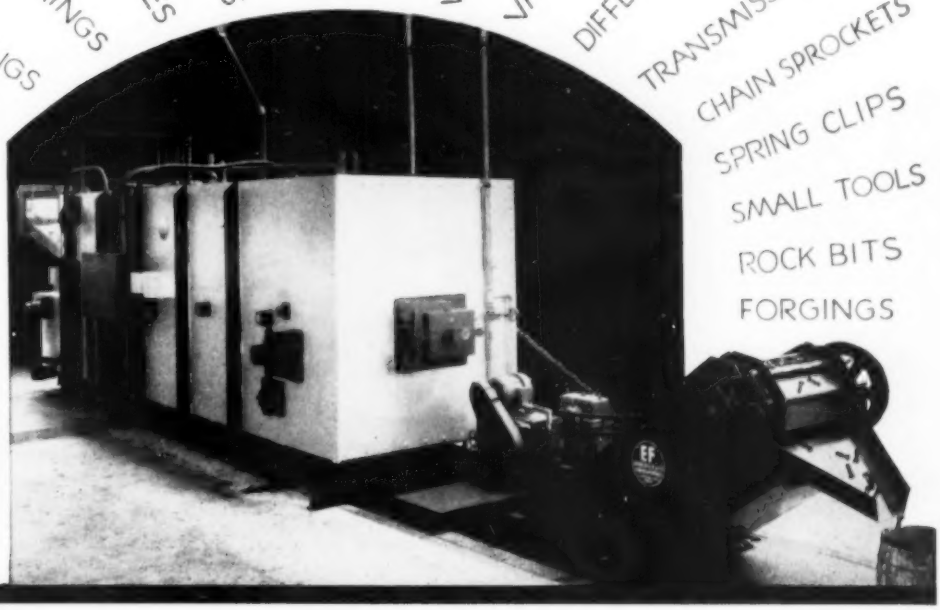
• Index to Advertisers •

TOWER PRINTING CLEVELAND

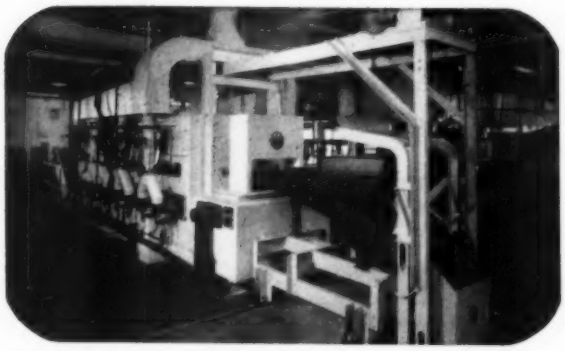
BALLS FOR BEARINGS
SPRING PLATES
CAP SCREWS
PINIONS
BOLTS - NUTS
RIVETS
WRENCH PARTS
VALVE SPRINGS
DIFFERENTIAL GEARS
TRANSMISSION GEARS
CHAIN SPROCKETS
SPRING CLIPS
SMALL TOOLS
ROCK BITS
FORGINGS
ROLLER BEARINGS
TRACTOR LINKS
AIRCRAFT PARTS
WASHERS
ENGINE PARTS
COIL SPRINGS

ELECTRIC EF FURNACES FUEL FIRED



For Hardening Small Parts

Uniformly — Scale-free — Continuously, 175 to 2000 lbs. per hour



An EF Gas-Fired Radiant Tube Chain Belt Furnace Showing Labor-Saving Feeder. *(View at top)* An EF Electrically Heated Furnace Showing Automatic Quench and Discharge.

● The E F chain belt conveyor furnace is one of the most satisfactory continuous heating units yet devised for scale-free hardening, carbon restoration and non-decarb heat treating small and medium size parts. The material is loaded onto a rugged heat resisting cast link conveyor belt; carried through the furnace; heated uniformly to proper temperature; automatically quenched and discharged. No pans or trays are needed. Hundreds in daily operation prove the dependability and efficiency of our design. 11 standard sizes. Capacities to 2000 lbs. or more per hour. Gas, oil or electrically heated. Furnished complete with any desired feeding or discharging equipment. Write for folders describing our chain belt and other production furnaces.

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